U.S. Fish & Wildlife Service

The Value of Headwater Streams: Results of a Workshop, State College, Pennsylvania, April 13,1999

April 2000

Sponsored by:

Pennsylvania Field Office,
Suite 322, 315 South Allen Street,
State college, Pennsylvania

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TABLE OF CONTENTS

FOREWORD

The U.S. Environmental Protection Agency, U.S. Office of Surface Mining, U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, and West Virginia Division of Environmental Protection are cooperating in the preparation of an Environmental Impact Statement (EIS) on mountaintop mining operations and valley fills in the Appalachian coal fields. As announced in the ***Federal Register,*** the purpose of the EIS is to:

> **...**consider developing agency policies, guidance, and coordinated agency decision-making processes to minimize, to the extent practicable, the adverse environmental effects to waters of the United States and to fish and wildlife resources from mountaintop mining operations, and to environmental resources that could be affected by the size and location of fill material in valley fill sites.

As a result of the public **EIS** scoping process, the potential for valley filling to adversely affect streams emerged as a priority issue. The multi-agency EIS steering committee identified the following questions, among others, that need to be addressed during preparation of the EIS:

- How will we measure the effects (impacts) of mountaintop mining operations and associated valley fills on streams and aquatic life?

- What are the short- and long-term effects of individual mountaintop mining operations and associated valley fills on the physical, chemical, and biological conditions of affected streams and their watersheds, both within the area of direct impact and downstream? In answering this, consider water quality and quantity, changes in aquatic habitat, and stream use.

- What are the expected effects likely to be on aquatic species of federal and state concern (i.e., listed and proposed threatened and endangered species, candidate species, and species of special concern)?

- What are the relative individual and cumulative effects of a single large valley fill versus multiple small headwater fills? In answering this question, assess the relative value of headwaters and their contribution to the physical, chemical, and biological health of the larger watershed.

- How do we reach a better scientific consensus on the water quality/aquatic habitat values of valley headwater streams so that the on-site impacts of fills, and the resulting mitigation, restoration, and reclamation requirements can be judged more effectively -- both in the fill area and downstream? What does "minimize" environmental damages mean in this context?

- What criteria should be used to determine whether a fill may be placed in a stream?

- What is a stream? The agencies should develop a mutually acceptable approach for reconciling the interagency and interstate differences concerning the definition of streams.

To gather information relative to these questions, a one-day invitational meeting was organized by the Pennsylvania Field Office of the **U.S.** Fish and Wildlife Service to discuss the value of headwater streams. Experts from industry, government, and academia attended. In advance of the meeting, participants were sent the following list of questions, to be discussed at the meeting:

- What is a stream?

  At what point in the upper reaches of a stream do regulators stop regulating?

  How far upstream should we regulate to ensure that downstream functions and quality are maintained?

- Are stream classifications such as perennial, intermittent, or ephemeral ecologically useful or even relevant in this context?

- What indicators do we use to define these conditions? Flows? Fish presence? Invertebrate abundance and/or diversity?

- What can we afford to lose?

  - In evaluating the cumulative impacts of more than one valley fill, what size watershed do we evaluate?

  - How many streams can be eliminated by valley filling in a given watershed before the downstream aquatic ecosystem is unacceptably impaired?

  - If we assume that the amount of overburden material that needs to be disposed of is a constant, is one valley fill or a few very large valley fills better for the environment than more numerous small valley fills at the upper reaches of more valleys?

The meeting was held on April 13, 1999, in State College, Pennsylvania. Participants were informed that the meeting was being tape-recorded, and that the transcript would become part of the formal EIS record.

This report constitutes the meeting record, compiled from notes recorded during the meeting by EPA's Rebecca Hanmer, text slides or overheads used by presenters, and transcription of the meeting tapes by FWS's Cindy Tibbott. In addition, each presenter was given the opportunity to edit a draft transcript of his presentation. The meeting was informal and interactive, so discussions of various technical and regulatory issues are interspersed throughout the speakers' presentations and are delineated by use of a "SMALLCAP" font. Due to space limitations, many of the presenters' slides are not included here.

The State College meeting agenda also included a discussion of technical issues related to the EIS work plan for studying the effects of valley fills on streams. Because that discussion occurred early in the development of the study, and resulted in numerous follow-up discussions and iterations of the work plan, it is not included here.

The EIS steering committee extends its sincere appreciation to the speakers and participants for taking the time to share their expertise and insights on this important issue.

List of Participants

John Arway, Pennsylvania Fish and Boat Commission, Bellefonte, PA
Frank Borsuk, Potesta and Associates, Inc., Charleston, WV
Robert Brooks, The Pennsylvania State University, University Park, PA
Hope Childers, EPA, Wheeling, WV
David Densmore, U.S. FWS, State College, PA
Larry Emerson, Arch Coal, Huntington, WV
Diana Esher, EPA, Philadelphia, PA
Jim Green, EPA, Wheeling, WV
Steven N. Handel, Rutgers University, Bridgewater, NJ
Rebecca Hanmer, EPA, Washington, D.C.
Dave Hartos, OSM, Pittsburgh, PA
William Hoffman, EPA, Philadelphia, PA
Steve Kepler, Pennsylvania Fish and Boat Commission, Bellefonte, PA
George Kincaid, U.S. Army Corps of Engineers, Apple Grove, WV
Fred Kirschner, U.S. Army Corps of Engineers, Apple Grove, WV
Jerry Legg, Virginia DMME, Big Stone Gap, VA
Bernie Maynard, OSM, Pittsburgh, PA
Dan McGarvey, The Pennsylvania State University, University Park, PA
Dennis Newbold, Stroud Water Research Center, Avondale, PA
Maggie Passmore, EPA, Wheeling, WV
Ken Politan, WV DEP, Nitro, WV
Randy Pomponio, Canaan Valley Institute, Valley Forge, PA
Dan Ramsey, FWS, Elkins, WV
David Rider, EPA, Philadelphia, PA
Mike Robinson, OSM, Pittsburgh, PA
Craig Snyder, U.S.G.S. - BRD, Kearneysville, WV
Jay Stauffer, The Pennsylvania State University, University Park, PA
Don Stump, OSM, Pittsburgh, PA
Bernard Sweeney, Stroud Water Research Center, Avondale, PA
Cindy Tibbott, FWS, State College, PA
J. Bruce Wallace, University of Georgia, Athens, GA
John Wirts, WV DEP, Charleston, WV
John Young, U.S.G.S. - BRD, Kearneysville, WV

About the Presenters. . . .

Larry Emerson is Director of Environmental Performance with Arch Coal, Inc., in Huntington, West Virginia. He has a Bachelors degree in Agronomy from Virginia Tech (1978) and has been in the coal mine reclamation and environmental compliance field for 21 years. His professional affiliations include membership in the West Virginia Association of Professional Soil Scientists and the American Society for Surface Mining and Reclamation.

Denis Newbold is a Research Scientist at the Stroud Water Research Center where he studies nutrient cycling, organic particle transport, and riparian zone influences in stream ecosystems. He received a B.S. in engineering from Swarthmore College in 1971, an M.S. in hydrology from Cornell in 1973, and a Ph.D. in aquatic ecology from the University of California in 1977. From 1977 through 1983 Denis worked in the Environmental Sciences Division at Oak Ridge National Laboratory, where he was involved in both theoretical development and experimental analysis of the nutrient spiraling concept. Since joining the Stroud Center (then part of the Academy of Natural Sciences of Philadelphia) in 1983, his work has included modeling temperature influences on insect life histories, experimental studies of the spiraling of dissolved and particulate organic carbon, and investigations of the role of riparian forest buffers in mitigating nonpoint source pollution.

Jay R. Stauffer, Jr., has been working on the systematics, ecology, distribution, and behavior of stream fishes for more than 25 years. He received his B.S. from Cornell and his Ph.D. from Virginia Polytechnic Institute and State University. He co-authored a text on the Fishes of West Virginia, and is currently revising the Fishes of Pennsylvania. He has published some 140 articles in referred journals and is currently Professor of Ichthyology at the Pennsylvania State University.

Bernard Sweeney is presently Director, President, and Senior Scientist at the Stroud Water Research Center in Avondale, Pennsylvania, and an adjunct Professor at the University of Pennsylvania. The Stroud Center was founded in 1967 and is focused on producing new knowledge, greater understanding, and better appreciation of streams, rivers, and their watersheds through programs emphasizing basic and applied research and environmental education. Bernard has a Ph.D. from the University of Pennsylvania (1976) in Zoology and has published research papers on the following topics: Population and community ecology of aquatic invertebrates, the role of streamside forests in the structure and function of stream and river ecosystems, the effects of global warming on stream ecosystems, genetic variation and gene flow among populations of stream insects, factors affecting the growth and development of aquatic insects, bioenergetics and secondary production of aquatic insects, and the bioassay of toxic materials in aquatic systems.

J. Bruce Wallace received his B.S. from Clemson University, and M.S. and Ph.D. from Virginia Tech. He is currently Professor of Entomology and Ecology, University of Georgia, Athens, Georgia, where he teaches courses in stream ecology, aquatic entomology, and immature insects. He has served as major professor of some 38 graduate students at Georgia. Dr. Wallace is author, or co-author, of some 150 scientific papers, including book chapters concerned with various aspects of stream ecology, or aquatic entomology. Much of his research during the past 25 years has been conducted on southern Appalachian streams at the Coweeta Hydrologic Laboratory (U.S. Forest Service) in western North Carolina and supported primarily by the National Science Foundation. His primary research areas include: linkages between streams and terrestrial ecosystems; role of aquatic invertebrates in stream processes; effects of disturbance and recovery of streams from disturbance; secondary production and aquatic food webs and energy flow; and organic matter dynamics in headwater streams. Dr. Wallace is a past president (1991-1992) of the North American Benthological Society. He was the recipient of the 1999 Award of Excellence in Benthic Science from the North American Benthological Society.

EXECUTIVE SUMMARY

Mountaintop mining is a form of strip mining that uses large equipment to access multiple coal seams across large tracts of land. The terrestrial landscape is dramatically altered, and streams are filled with overburden material. Over the last approximately **20** years, the size of individual operations has increased, as has the number of mountaintop removal mines, leading to public concern over the cumulative environmental and social impacts of this mining method across Appalachia.

To help assess the potential impact of stream filling activities on the aquatic ecosystem, a one-day invitational meeting was organized by the Pennsylvania Field Office of the U.S. Fish and Wildlife Service to discuss the value of headwater streams. The speakers focused on the description of the mining method and the headwaters environment in which it is carried out. Special emphasis was placed on the ecological context and importance of headwater streams within the larger aquatic ecosystem.

Larry Emerson (Arch Coal) provided an overview of large-scale mountaintop mining as it is practiced in West Virginia. The demand for low-sulfur coal is the purely economic force driving the increase in mountaintop mining. This mining method allows companies to recover 85 to 90 percent of the coal resource. Companies are able to use large-scale mining because of their ability to put together large, contiguous tracts of land in West Virginia. Production costs are primarily in moving rock. This mining method is best employed on coal seams within the Stockton level and above, in southern West Virginia. These areas have already been deep- and contour-mined in the past, so there are few untouched coal reserves remaining. The estimated life of large-scale mining in the state is about 15 more years.

Mr. Emerson stated that, in the creation of the post-mining topography, there is real potential for water resources to be maximized so that wetlands and stream channel areas with biotic communities can be created. In addition, there is a great potential for re-mining pre-SMCRA mine sites, reclaiming them and bringing them up to today's standards in the process.

Bruce Wallace (University of Georgia) has been studying headwater streams at the Coweeta Hydrologic Laboratory in western North Carolina for 30 years. He has conducted a number of experiments that demonstrate the reliance of stream biological communities on inputs from the surrounding forests. For example, when leaf litter was excluded from a stream, the primary consumer biomass in the stream declined, as did invertebrate predators and salamanders (there are no fish in these small streams; salamanders are the only vertebrate predators). Overall, leaf litter exclusion had a profound effect on aquatic productivity, illustrating the direct importance of terrestrial-aquatic ecotones. Other experiments illustrated the fact that, while invertebrates and microbiota in headwater streams are only a minute fraction of living plant and animal biomass, they are critical in the export of organic matter to downstream areas by converting leaf litter to fine particulate organic matter, which is much more amenable to downstream transport than the leaves themselves are. Organic matter transport to downstream reaches totals about 1 kg of export per meter length of stream on an annual basis, and comprises a large proportion of the food supply for invertebrate populations downstream, which in turn become food for fish populations.

Dr. Wallace raised the concern that stream thermal regimes, which can have important influences on microbial activity, invertebrate fauna and fish egg development, larval growth, and seasonal life cycles, may be affected by valley fills and sedimentation ponds at the base of the valley fills. In addition, with the documented increases in nitrogen deposition that are occurring in eastern North America, we need to understand what is happening to nitrate concentrations in streams emerging from valley fills.

Dr. Wallace expressed concern that this mining practice is eliminating first order streams with no requirement for pre-impact biological inventories. Streams in the southern Appalachian region have been found to harbor outstanding biological diversity, with rare species known to occur in only one or two springbrooks or seepage areas.

Bernard Sweeney (Stroud Water Research Center) provided insights into the value of headwater streams based on research in southeastern Pennsylvania that has been ongoing since 1968. The Center's Robin Vannote formulated what has become known as the "River Continuum Theory," which views the stream ecosystem as a continuum from the first order headwater streams down through the larger order rivers. Results from the first few years of research at the Center demonstrated that first order streams are both abundant and crucial to the overall function of the ecosystem.

Dr. Sweeney emphasized the relationship between streams and the surrounding terrestrial environment. As wet depressions in the landscape, leaves tend to blow across the forest floor and get stuck in the streams. Very little of this coarse organic material (leaves) is transported downstream; most is processed by living organisms. Streams flowing through grassy areas have much lower inputs of coarse organic material than streams flowing through forests; this is a concern regarding the concept of reconstructing streams in grassy reclamation areas. Different kinds of leaves (from different species of trees) affect the production and biomass of invertebrates. In addition, as precipitation percolates through leaves on the forest floor, it extracts organic compounds from the leaves, similar to the effect of steeping a tea bag in hot water. These dissolved organic compounds -- "watershed tea" -- are carried to the stream by groundwater and drive a major portion of the aquatic system's productivity.

The stream bottom is the crucial site of biological and biochemical activities in stream systems. About **32** percent of the total bottom area in the White Clay Creek watershed is in first order streams. High species diversity is typical of benthic invertebrate populations in small headwater streams. Densities of invertebrates are similar in small, first order streams and larger streams, but the fact that there is so much benthic area available in small streams, and there are so many of them, mean that collectively the headwaters account for abundant production in the system.

The turnover of benthic invertebrate species is high as you travel down through the river continuum; there are few species in the headwaters that also occur downstream in a large river. This raises the question of what happens if headwater streams are eliminated. If a species occurs only in first, second and third order streams, and the first and second order streams are eliminated, how long can the third-order population persist? Because human developments typically concentrate along third, fourth, and fifth order streams, this is where accidents will happen that destroy aquatic life. Recolonization would occur through organisms moving in from the upstream, smaller tributaries -- but only if the tributaries still exist.

Dr. Sweeney cautioned that the area of eastern West Virginia and western Virginia are hotspots of new species discovery, due to thermal diveristy, and the lack of glaciation which allowed time for species to evolve. The aquatic insects of this area haven't even been fully characterized yet, and we can't afford to destroy what we don't know.

Denis Newbold (Stroud Water Research Center) discussed Webster and Wallace's concept of nutrient spiraling, which is a way of assessing the effectiveness of an ecosystem at processing nutrients. The tighter the nutrient spiral, the more effective the ecosystem is at trapping and reusing organic matter and nutrients as you move downstream. The spiraling length is relevant to the mountaintop removal issue, because it gets at the question of where, if you're an organism living in a downstream ecosystem, your nutrients originated.

In a typical stream carbon cycle, much of the dissolved organic carbon (DOC) in a stream is refractory (it doesn't get used very fast, and is transported great distances downstream). On the other hand, a significant portion of the DOC is labile, and it cycles within the stream ecosystem. About half of the labile DOC produced within any given reach of stream will be utilized within that reach, while the remainder is passed to a larger downstream reach. The next reach (the next order stream) will have a proportionately longer turnover length. Each downstream reach uses a portion of the labile DOC passed from upstream, and passes the remainder downstream. The downstream transfer and utilization of carbon successively cascades downstream. Turnover lengths also vary depending on the type of material being transported. Very fine particulate organic matter can move 10,000km downstream, generally putting it into the ocean; refractory can move even farther, and on its way it feeds larger streams, rivers, and estuaries. While there is a wide range of stream ecosystem efficiency, the median is about 50% regardless of the size of the watershed.

Dr. Newbold discussed a possible scenario for the organic content of streams emerging from the toe of a valley fill. Precipitation will pick up organic matter from the revegetated valley fill surface, percolate through the fill, and eventually emerge below the fill as water with low-concentration refractory, possibly even at concentrations similar to what would have been there without the fill. However, the stream emerging from the fill will be missing the labile dissolved and particulate organic matter that would have been produced by the stream that is now buried, and it is this labile portion, produced by the stream itself, that supports downstream metabolism.

Summarizing, Dr. Newbold explained that a significant portion of exported organic matter originates within the stream and is labile. Soil and riparian areas next to the stream are major sources of carbon, and the decomposition of litter and the primary production of material in the stream are also important sources of organic matter that get exported downstream. Most of the organic matter inputs to mid-order streams originated from first and second order streams; between 60 and 80% of the water feeding a fourth-order stream came from first and second order streams. If you're in a fourth order basin, and you eliminate the first and second order streams, you eliminate half of the water and drainage area and stream bed area to the downstream larger order.

Jay Stauffer (Pennsylvania State University) discussed eliminating headwater streams from the standpoint of fish populations that occur in these areas.

Dr. Stauffer discussed many factors that lead to speciation in fish in headwater streams. It is a common misconception that fish fauna are well-known, and that there are no unique fish present in the coalfields' headwater streams. In fact, many headwater streams have fish populations that have become isolated due to any number of causes, and minimal gene flow with the main population results in the development of new species. These species may occur only in one or two small streams, and nowhere else.

These streams may even support populations of migratory fish, such as lampreys. Other species may move into headwater streams at certain times of the year, but won't be found there at other times.

Dr. Stauffer discussed the concepts of ecosystem inertia and elasticity. Inertia concerns the ability of a stream to withstand stress before structural components of the ecosystem change. Headwater streams may only have two or three species of fish, so there is little functional redundancy built into the fish community. The loss of one species would mean the loss of one-third of the fauna, which is a structual change. This causes a more drastic impact on the ecosystem than it would if a species were lost in a larger stream that supported many species. Other factors, such as buffering capacity, or how close the stream is to a major ecological threshold -- such as thermal limits -- are involved in determining a stream's inertia.

The elasticity of the system considers such factors as whether or not there are epicenters nearby that could provide organisms to reinvade a damaged ecosystem. In many headwater streams with unique fish or invertebrate species, there simply are no epicenters from which recolonization can take place -- these organism may only occur in one place. These headwater streams are very fragile and have very low inertia, and their ability to recover from stress is probably compromised because they are so unique and so different. Dr. Stauffer argues that we should not be taking chances with streams that support genetically unique aquatic life, because we can't risk losing that genetic diversity.

Dr. Stauffer discussed the possibility of "recovery" of stream ecosystems by trying to recreate streams on the mine benches, stressing that the goals of the recovery effort must be clearly articulated in advance: Do we want the stream or ecosystem back to the way it used to be? Is it satisfactory if something can just live in the system? If something different lives in the system, is it satisfactory if it serves the same basic functions as the original?

Larry Emerson, Arch Coal, Inc., Huntington, West Virginia

I'd like to first, illustrate in schematics and photos the process of large-scale mountaintop mining as it's practiced today in West Virginia, with particular emphasis on valley fills, which seem to be the focus of all these efforts. Secondly, to point out the relative value of some of these reclaimed sites with respect to water resources, and also to emphasize the potential of some of these post-mining sites to have some water resource value. Also, to touch on the reality that some mountaintop mining operations in existence today are going in and remining previously-mined, pre-law sites, and there is yet additional potential to remediate past mining scars from back in the '40's and '50's. I also have a slide on the areal extent of mountaintop mining in West Virginia from the West Virginia Geological and Economic Survey. Also, I can offer some of our mines for consideration as sites to be studied during the process. Should they fit the criteria, we offer them for consideration.

With respect to Arch's West Virginia operations, we have four of the six largest mining complexes in West Virginia. These four sites have walking draglines -- the large-scale equipment which allows us to compete under today's economic conditions. Just so everyone understands, the reason for mountaintop mining in West Virginia today is purely economics and markets. Demand for low sulfur coal is driving the eastern coal market. The other large deposits of low-sulfur coal are in the Powder River Basin which is very cheap to produce, due to thick coal seams, some reaching 68 feet. West Virginia's seams are more like 4 - 6 feet. With mountaintop removal, we can recover 85 to 90 percent of that coal resource, whereas with other mining methods it's sometimes significantly less than that. It is the large-scale ability to put together contiguous leased tracts of land in West Virginia (and there are historical reasons for that) that have allowed this type of large-scale mining to take place.

This is a schematic showing a typical dragline operation in West Virginia. The analogy I like to make is with a layer cake. If you take a slice through these mountains, it's like a layer cake with the fudge icing being the coal seams and the sandstone and shale strata in between the coal seams representing the cake. Some of these mountains contain 11 - 12 coal seams, mostly oriented horizontally, but there is some localized roll and dip in the seams. The first stage in the mining operation is to clear the area of vegetation (usually the landowner is responsible for this stage). The upper elevations of the mountain are then drilled, blasted, and excavated to recover the first coal seam. That overburden is deposited in the only available, stable place to put it, which is in the adjacent valley. That process proceeds downward to the lower elevations until you reach a certain coal seam elevation where the dragline is then deployed. The dragline then excavates down to the bottom two coal seams. The function of the dragline is basically to pick up the rock strata from point A and moves it to point B. The dragline excavation moves laterally through the mountain, uncovering these coal seams. Smaller equipment extracts the coal. Reclamation follows with bulldozers, resculpting the area to its post-mining topography with some rolls and undulations. It is possible to do a fair amount of creation in terms of how you re-grade to the post-mining topography. There's real potential here for post-mining water resources to be optimized so that there can be some addition of stream channel areas with which there could be some biotic communities restored.

Here's how it works operationally, at the Catenary Mine in Kanawha County: The upper horizons are excavated with smaller equipment, such as loaders and trucks. Then the electric shovel excavates down through the middle horizons, uncovering one or more coal seams from the top downward. Finally the dragline is utilized to uncover the lower coal seams. The dragline and shovel only move rock. We're basically rock miners, because we move multiple cubic yards of rock to recover one clean ton of coal, so our production costs are mainly in moving rock. Finally, the overburden is re-graded and shaped to its post-mining topography, which can be gently rolling with undulations and watercourses that approximate the pre-mining topography. So it's in this post-mining topography where we have a real potential to put in basins, check dams, stream channels, to recreate water areas where you can capture rainwater, allow it to accumulate or pool up, and there's potential to create wetland resources.

Now for an explanation of valley fill construction, the first order of business is sediment control. You go into your permitted valley fill area and construct the sediment control structure, which is designed on the maximum amount of the disturbed watershed behind it. West Virginia requirements are 0.125 acre-feet of sediment storage capacity for each acre disturbed. The actual construction of the fill begins at the headwaters; the excavated rock material is placed first at the headwater areas, then progresses downstream. Proceeding on, this is your classic end-dump valley fill, where the larger rock, just by shear gravity and segregation, rolls down to the bottom, creating internal drainage through the fill. There are still going to be some perched aquifers on either side of the hollow, and there will also be some surface runoff -- this reality is accounted for in the design process and the result is that these structures are somewhat porous and there's a fair amount of infiltration. The big rocks that roll down to the bottom provide void spaces and places for water to be stored. When you reach the permitted extent of the valley fill, you put in post-mining sediment control and drainage ditches. These are generally 50-foot vertical lifts with 20-foot horizontal benches, with a certain percentage grade down to the center (this is the center core fill). Some fills are side drained fills, with groin ditches on each side (different fill design). The final stage requires certification by a registered professional engineer and revegetation.

During the active phase of mining, the area is open to the elements and weathering. This phase can run from 6 to 18 months in length. However, all surface runoff is channeled through a sediment control structure and regulated as a point source under the Clean Water Act. After final reclamation, the post-mining topography lends itself to re-creation of water resources. Ponds, basins, check dams, and bench sediment control structures are all designed to handle the surface runoff from predetermined rain events under the Surface Mining Act. It is with these structures that wetland resources could be created on the mine site.

There's also a lot of potential to remine previously mined areas (pre-law) -- these can be reclaimed and brought up to current standards. These examples are from the Catenary site. Old refuse fills that have been abandoned prior to 1977 can be capped over and reclaimed using modem mining methods [showed slide of reclaimed area]. Old slurry impoundments have been eliminated as part of the mitigation process; when some of these sites are reclaimed, current law allows mitigation credits. There are opportunities for creating wetlands for treating pre-law discharges. There's a substantial body of knowledge out there on re-creating wetlands, and there's lots of potential to do this on older mine sites.

This slide is another illustration of some of the post-mining water resources suitable for aquatic life. Some of them are even flowing. The top of a valley fill is shown on the slide, with a wide bench on the perimeter. SMCRA does not allow standing water on valley fills, but there are a lot of other areas of the reclaimed site that lend themselves very well to wetland resources. We can construct basins and settling ponds to capture rainfall, and over time infiltration occurs through the backstack that ultimately can provide a post-mining spring in certain limited circumstances. Another example is a perimeter ditch around the periphery of the mine site.

The Hobet 21 site was the first area to use a walking dragline in West Virginia, in 1983. We've had 15 years of large-scale mining at that site. The area now has over 50 valley fills. It lies in the upper Mud River drainage. This site may provide opportunities for study.

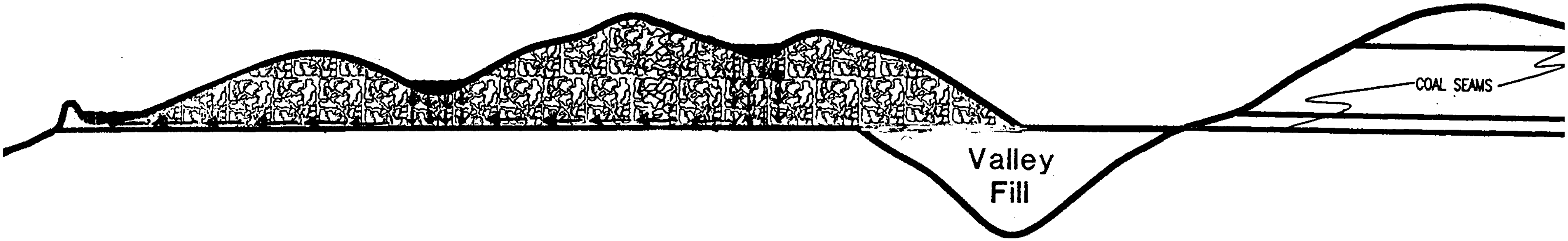
This overhead (Figure 1) reinforces the concept of back-filled areas and valley fills to present opportunities for post-mining water resources. We have found through experience that valley fills are porous in nature and water becomes stored within the fill. This stored water is continuously released to the receiving stream, and provides significant flow during extended dry periods.

This overhead (Figure 2) shows a typical cross section of a valley fill, using center core construction method, where you're dumping from the headwaters and on each side laterally as this is constructed from the headwaters on down to the mouth. As you can see, the larger rocks roll to the center and to the bottom and creates that porous area. There is water flowing from the toe of these areas. With regard to the backfill areas, this overhead represents the undisturbed solid area just below the lowest coal seam that was mined. This barrier acts as an aquaclude and prevents the downward infiltration of water. As we construct basins, channels, and ponds on top, some water infiltrates, reaches the shale underlying the lowest coal seam, and stops there and flows down-gradient and pops out at the toe of one of the outslopes, and in several occasions there is flowing water coming out of these sites.

KINKAID -- DEFINE BACKFILL. **EMERSON** -- BACKFILL IS ROCK STRATA THAT IS REMOVED DURING THE MINING PROCESS TO UNCOVER THE COAL SEAM, AND IS DEPOSITED ON TOP OF THE SOLID BENCH WHICH IS REPRESENTED AS THE HORIZONTAL DISTANCE FROM ONE SIDE OF THE MOUNTAIN TO THE OTHER. BY CONTRAST, THE VALLEY FILL MATERIAL IS DEPOSITED ADJACENT TO THE BENCHED BACKFILL AREA (SEE DRAWING). BACKFILL IS COMPOSED OF SANDSTONE, SHALE AND OVERBURDEN, OR INTERBURDEN WHICH IS ROCK FROM IN BETWEEN COAL LAYERS. THIS MATERIAL IS PICKED UP BY THE DRAGLINE AFTER IT'S BEEN DRILLED OR BLASTED, THE DRAGLINE TURNS AROUND 90 DEGREES, AND DEPOSITS THE MATERIAL SOME 200 FEET TO THE SIDE. THIS "SPOIL PILE" IS THEN RESCULPTED TO ITS POSTMINING

EXPLANATION

- Backfill Material
- Water Percolation Path
- Undisturbed Rock Strata (barrier to downward percolation of water)
- ⟵ Direction of Groundwater Flow



<u>REGRADED SECTION OF BACKFILL ON SOLID BENCH</u>

Backfilled rock material is very permeable and allows rainwater to percolate through and become stored as groundwater. This new recharge area then becomes the source of water for post mining streams and seeps.

FIGURE 1.

Typical Cross Section Of Finished Valley Fill

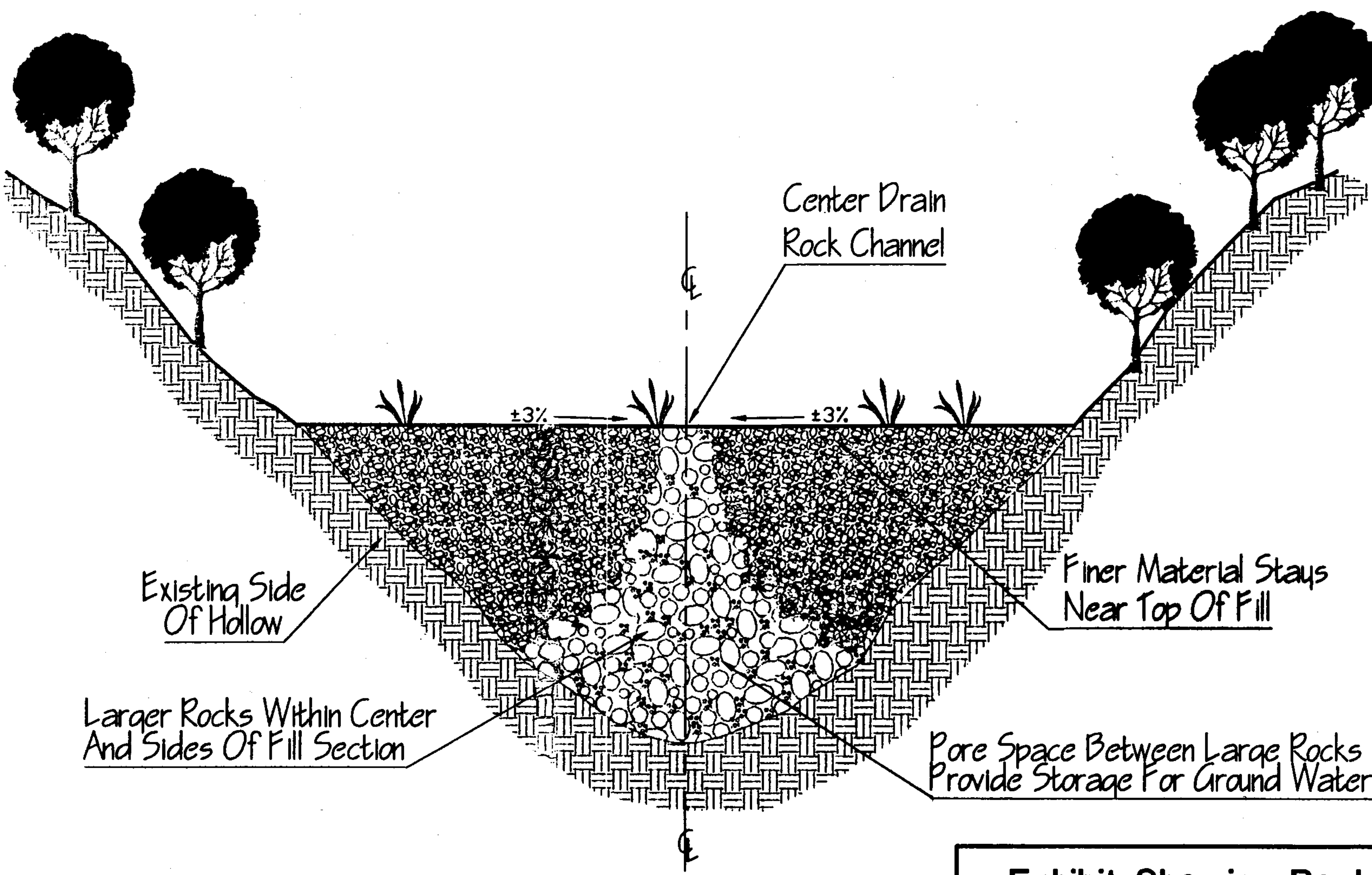


Exhibit Showing Rock Blanket And Ground Water Storage Capacity Of Fill

FIGURE 2.

TOPOGRAPHY. KINKAID - IS IT COMPACTED OR JUST DROPPED? EMERSON - IN THE CASE OF THE DRAGLINE EXCAVATION, IT'S JUST DROPPED. WITH RESPECT TO COMPACTION, THERE'S SOME COMPACTION GOING ON WHEN YOU'RE RESCULPTING THIS, WHEN YOU PUT A DOZER ON THERE. REMEMBER THE SPOIL PILES ARE FAIRLY SHARP WHEN YOU FIRST DEPOSIT THEM, THEN YOU PUT BULLDOZERS ON THEM TO SHAPE THEM OFF, MAKE THEM SMOOTHER, AND PREPARE THE SEED BED. THERE'S AT LEAST SOME COMPACTION THAT GOES ON THERE WHEN YOU HAVE THE BULLDOZERS RESHAPING.

KINKAID - WITH SANDSTONE AND SHALE, THERE IS SOME POTENTIAL FOR ACID LEACHING, GIVEN THE COMPOSITION OF THE 5 BLOCK COAL. WHAT IS PUT ON THE SURFACE FOR REVEGETATION? EMERSON - SOMETIMES, TO THE EXTENT NATIVE SOILS CAN BE SALVAGED AND REDISTRIBUTED, THAT HAPPENS, BUT THAT'S MORE AN EXCEPTION RATHER THAN THE RULE. THERE IS A PROVISION IN THE REGULATIONS THAT ALLOWS FOR AN ALTERNATE TOPSOIL MATERIAL TO BE USED IF CAN BE TESTED AND SHOWN TO BE THE "BEST AVAILABLE" THAT IS WITHIN THE STRATA. IF IT'S TESTED AND SHOWN TO HAVE GOOD SOIL MEDIUM CHARACTERISTICS AND YOU PUT TOGETHER A HANDLING PLAN THAT SHOWS HOW YOU RECOVER THOSE PARTICULAR STRATA AND USE THEM AS SOIL MEDIUM, THIS TENDS TO BE THE RULE: WE'RE BASICALLY CREATING NEW TOPSOILS FROM SHALE AND SANDSTONE THAT EXISTS WITHIN THE MOUNTAIN PRIOR TO MINING. IT'S BEEN OUR EXPERIENCE THAT IT'S VERY CALCAREOUS IN NATURE (PASTE PH BETWEEN 6.5-7.5), WITH A FAIR AMOUNT OF CALCIUM AND MAGNESIUM, WHICH DOES CERTAINLY INCREASE THE TDS OF POST-MINING WATER QUALITY. THERE'S NO DOUBT ABOUT THAT. IT DOES INCREASE THE BUFFERING CAPACITY AS WELL.

KINKAID - YOU'RE PLACING SOIL OVER THE VALLEY FILL AND BACKSTACK MATERIAL? EMERSON - YOU MEAN SALVAGING NATIVE TOPSOILS? KINKAID - I'M WONDERING WHAT'S ON TOP OF THE BACKSTACKED MATERIAL AND VALLEY FILL FOR THINGS TO GROW? EMERSON - IT'S GENERALLY A MIXTURE OF SANDSTONE AND SHALE THAT'S IN THE INTERVAL BETWEEN THE 5 BLOCK AND STOCKTON FORMATIONS WHICH IS A MIXTURE THAT WINDS UP ON TOP OF THE SPOIL PILE AS A RESULT OF THE EXCAVATION. WE HAVE FOUND THAT SINCE PH IS FAIRLY HIGH AND THE MATERIAL WEATHERS FAIRLY READILY, THAT PARTICLE SIZE DISTRIBUTION, ALTHOUGH FAIRLY SANDY, STARTS TO APPROACH LOAM IN MOST CASES. WE ADD NITROGEN, PHOSPHOROUS, AND POTASSIUM AND SEED MIXTURE, MOSTLY THROUGH HYDROSEEDING. IT ACTUALLY GROWS HERBACEOUS COVER VERY WELL. WHAT GOES ON THERE IS PART OF THE PROCESS OF EXCAVATING THE MATERIAL. AFTER THE STRATA HAS BEEN BLASTED AND RE-HANDLED, YOU PUT THE BULLDOZERS ON TO RE-SCULPT IT, YOU GET A FAIR AMOUNT OF FINE MATERIAL DURING THE PROCESS. WE THEN SPRAY OUR MIXTURE OF GRASSES, LEGUMES, FERTILIZERS AND MULCH AND IT GROWS THAT GRASS/LEGUME MIXTURE VERY WELL. SO OVER TIME YOU'RE BASICALLY CREATING A NEW SOIL AS A RESULT OF USING THIS BRAND-NEW PARENT MATERIAL. KINKAID - DO TREES GET ESTABLISHED? TREES ARE HAND-PLANTED AFTER HERBACEOUS COVER IS ESTABLISHED, BECAUSE OF EROSION CONTROL REQUIREMENTS. THAT DOES PRESENT SOME PROBLEMS IN GETTING TREES ESTABLISHED QUICKLY. WE HAVE FOUND THAT PIONEER SPECIES TEND TO COMPETE WELL WITH GRASSES AND THEY HAVE AN EDGE OVER NATIVE HARDWOODS. GENERALLY POPLARS, MAPLES, ASH, BIRCH, BLACK CHERRY, ETC., WILL GROW FAIRLY WELL AND COMPETE WITH THE GRASSES AND LEGUMES THAT ARE ALREADY ESTABLISHED. IT'S GENERALLY MUCH MORE DIFFICULT TO ESTABLISH HARDWOODS. WE HAVE FOUND THAT BY GOING TO OLDER SITES THAT WERE MINED IN THE MID-70S, ON THE OUTSLOPES WHERE MATERIALS WERE PUSHED OVER AND NOT COMPACTED, AND NOT ANY KIND OF POST MINING SEEDBED PREPARATION TOOK PLACE, WHERE IT'S LEFT LOOSE AND ROUGH -- THOSE GENERALLY WERE MUCH MORE CONDUCIVE TO NATURAL SUCCESSION OF HARDWOODS ONTO THESE SITES. ON TOP OF THE OLDER 20-YEAR OLD SITES, WHERE THERE WAS A FAIR AMOUNT OF COMPACTION, NATIVE TREES HAD A HARDER TIME. SO COMPACTION PLAYS IN A ROLE IN THAT.

KINCAID - WHEN MATERIALS ARE RELOCATED TO VALLEY FILL AND BACKSTACK LOCATIONS, HOW ARE THEY CHARACTERIZED AS TO ACID-BASE ACCOUNTING AND THE PHYSICAL CHARACTERISTICS OF THE ROCK -- WHAT ABOUT THE MATRIX WHICH CEMENTS THE SANDSTONE. IS THE MATRIX SUBJECT TO ATTACK BY NATURAL WATERS OR WATERS THAT MAY BE ALTERED AS A RESULT OF FLOW-THROUGH? EMERSON - THERE'S A FAIR AMOUNT OF PREMINING GEOLOGIC CHARACTERIZATION DURING THE APPLICATION PROCESS. CORES ARE DRILLED PRIOR TO MINING, AND ALL OF THE ROCK STRATA GO THROUGH AN ACID-BASE ACCOUNTING TO DETERMINE THE ACID-PRODUCING POTENTIAL FOR EACH STRATA. THERE IS A NET BALANCE DETERMINED TO DETERMINE WHETHER STRATA IS A NET NEUTRALIZER OR NET ACID PRODUCER. IF YOU FIND AREAS THAT ARE NET ACID PRODUCERS, YOU HAVE TO SPECIAL HANDLE THOSE LAYERS OF ROCK AND SEGREGATE THOSE AND HANDLE THEM THROUGH A SPECIAL HANDLING PLAN. GENERALLY, IN SOUTHERN WEST VIRGINIA, THESE HAVE BEEN DESCRIBED BY GEOLOGISTS AS MARINE DEPOSITS AND IN MOST CASES ARE CALCAREOUS. THE MATRIX IS CALCIUM CARBONATE BASED; NOT LIMESTONE, BUT IT DOES HAVE A FAIR AMOUNT OF CALCAREOUS MATERIAL AS A CEMENTING AGENT. THE SHALES TEND TO BREAK DOWN READILY WITH WEATHERING

AND ARE ALSO CALCAREOUS IN NATURE, SO IN MOST CASES THERE IS RAPID DETERIORATION OF THE STRUCTURE, FORMING A FAIR AMOUNT OF SAND- AND SILT-SIZE MATERIALS FOR PLANT GROWTH.

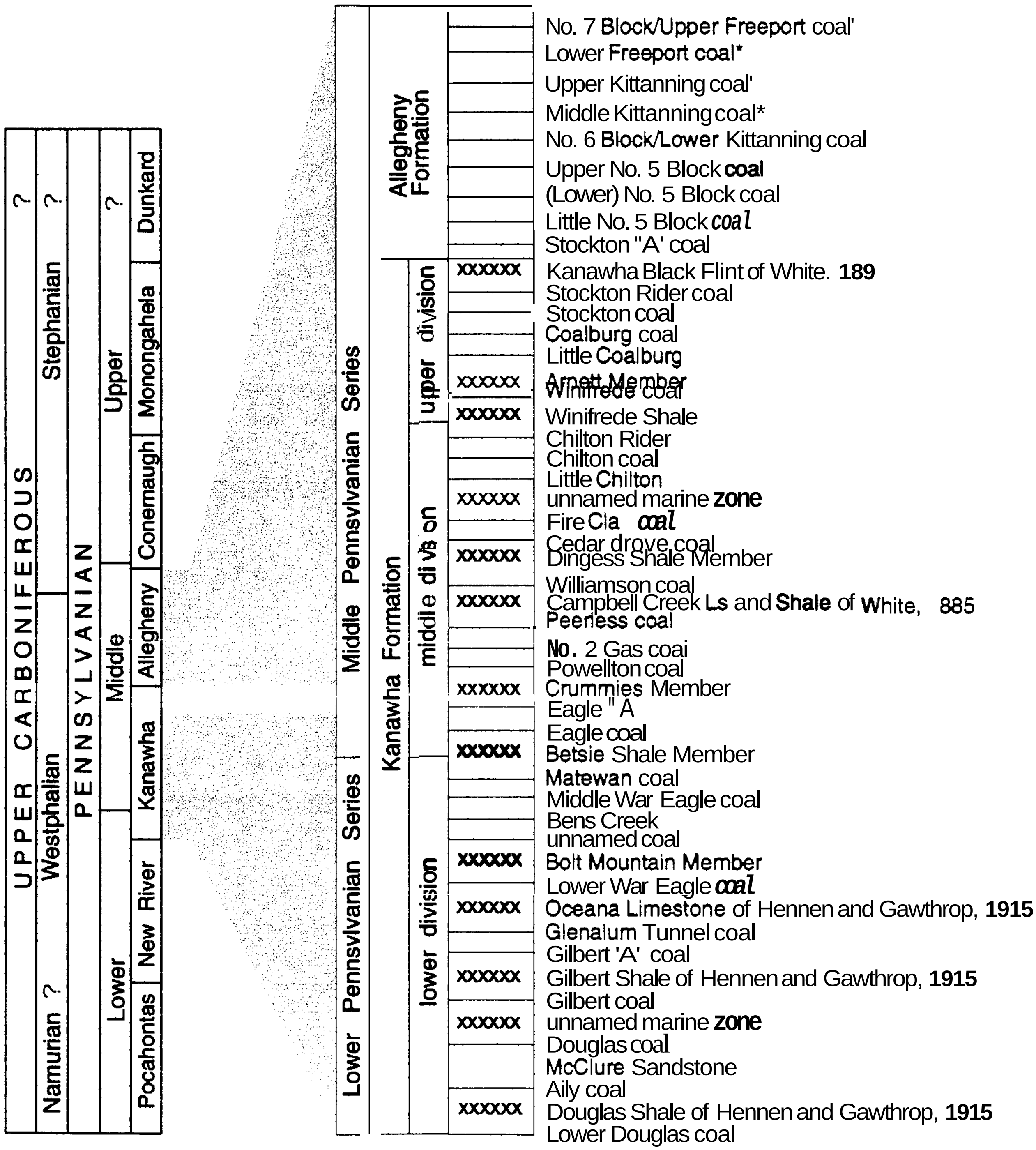
KINKAID - IT WOULD SEEM THESE MATERIALS COULD CRUMBLE IN A WAY THAT COULD AFFECT SLOPE AND STABILITY OF THE FILL. **POLITAN** - WE HAVE DURABLE ROCK TESTS, TOO. FOR DURABLE ROCK FILLS, THEY HAVE TO PASS CERTAIN TESTS TO BE PLACED IN A VALLEY FILL. **EMERSON** - SLAKE DURABILITY TESTS ARE DONE ON MATERIALS THAT ARE GOING TO BE PLACED IN THE VALLEY FILLS; THEY HAVE TO STAND UP TO A CERTAIN AMOUNT OF ABRASION AND WEATHERING. IF THEY PASS THE SLAKE TEST, YOU'RE ALLOWED 80% DURABLE ROCK IN FILLS. REGARDING STABILITY OF THE BACKFILL, THE SLOPES ARE NO GREATER THAN 2:1 AND IN MOST CASES ARE MORE GENTLE SLOPES POST-MINING THAN PRIOR TO MINING. **KINKAID** - SO VALLEY FILLS HAVE STEEPER SLOPE? **EMERSON** - THE FACES OF THE VALLEY FILL ARE STAIR-STEPPED, AND THERE ARE ENGINEERING CALCULATIONS WHICH GO INTO SAFETY FACTORS WHICH DETERMINE THE FINAL SLOPE OF THE FACE, AND FOUNDATION STUDIES ARE DONE PRIOR TO MINING. YOU KNOW WHERE THE VALLEY FILL IS GOING, YOU KNOW WHAT THE SUBSOILS ARE IN THE CRITICAL AREA DOWN AT THE TOE, WHICH IS THE MOST IMPORTANT AREA TO BE AWARE OF, AND THERE ARE SOIL TESTS DONE THERE TO MAKE SURE IT HAS THE BEARING CAPACITY TO SUPPORT THESE STRUCTURES. INTERNAL DRAINAGE OF THESE STRUCTURES IS ALSO DESIGNED INTO THEM. ALL THAT IS LOOKED AT IN THE APPLICATION PROCESS AND REVIEWED, AND IF IT MEETS CERTAIN SAFETY CONSIDERATIONS, THEN THAT PARTICULAR CONFIGURATION IS PERMITTED. **KINKAID** - ARE TESTS DONE THAT RELATE TO LONG-TERM GEOCHEMICAL STABILITY OF THE FILL MATERIAL? **EMERSON** - IF IT MEETS THE SAFETY FACTORS, IT IS PRESUMED IT WILL BE STABLE LONG-TERM. (CONCERNING REFUSE FILLS AND SLURRY IMPOUNDMENTS, ADDITIONAL SAFETY FACTORS ARE ENGINEERED, E.G., EARTHQUAKE FACTORS.) VALLEY FILLS HAVE BEEN CONSTRUCTED IN THE SOUTHERN PART OF THE STATE FOR OVER 20 YEARS AND TO MY KNOWLEDGE THERE HAS NOT BEEN A SINGLE DOCUMENTED FAILURE OF ANY OF THESE STRUCTURES. THERE MAY HAVE BEEN A FEW MINOR SLUFFS AT THE FACE OF THE FILLS, BUT NO DOCUMENTED FAILURES, PRIMARILY BECAUSE OF THE SAFETY FACTORS INVOLVED IN THE ENGINEERING AND PRE-MINING PERMITTING REQUIREMENTS. **KINKAID** - SO IT WOULD BE FAIR TO SAY THAT THE EXISTING REGULATIONS ADDRESS THE PHYSICAL, MECHANICAL STABILITY. **EMERSON** - THAT WOULD BE A FAIR STATEMENT, YES.

With respect to the areas in West Virginia that are susceptible to, or available for large-scale mining, the West Virginia Geologic and Economic Survey has issued a report to the Governor's Task Force last October that indicated that most of the large-scale mountaintop mining takes place in the Allegheny and upper Kanawha formations, which have a geographic extent within the State where the coal seams lie relatively close to the top and are conducive to this type of mining (Figure **3).** With respect to what can be mined using these methods, it's generally from the Stockton level up. In a few cases you can surface mine the Coalburg, but generally it's a deep mine. Everything below that is either below drainage or too deep to be economically recoverable with large-scale surface mining.

Regarding the areal extent, the Geologic Survey mapped southern West Virginia -- the elevation of coal seams are proximate enough to the top of the mountains so it's potentially viable economically (Figure 4). Keep in mind these areas have been extensively deep-mined and contour-mined in the past. Over the long run, there are not many untouched coal reserves remaining; we think existing operations could go for another 15 to 20 years and then large-scale mining, by economic forces and depletion of reserves, will cease to exist as viable mining method.

DENSMORE - THE AREA YOU SHOW THERE IS AREAS OF MOUNTAINTOP REMOVAL MINING PRIMARILY? **EMERSON** - THAT'S CORRECT. **DENSMORE** - IF YOU LOOKED AT ALL SURFACE MINING (NOT JUST MOUNTAINTOP REMOVAL) THAT MIGHT INVOLVE VALLEY FILLING AND THEREFORE HEADWATER STREAMS/AQUATIC IMPACTS, HOW BIG AN AREA WOULD WE BE TALKING ABOUT? **EMERSON** - IF YOU LOOK AT CONTOUR MINING, WHERE YOU JUST TAKE A SLICE OUT OF THE SIDE OF THE MOUNTAIN AND FOLLOW THE OUTCROP AROUND THE MOUNTAIN, YOU COULD GO MUCH FARTHER INTO THE CENTRAL AND SOUTHERN AREA OF STATE, PERHAPS AS FAR NORTH AS CLAY AND BRAXTON COUNTIES. BUT BEAR IN MIND THAT THE "HINGE LINE," NORTHERN PART OF THE STATE HAS HIGHER-SULFUR RESERVES, WITH SOUTHERN WEST VIRGINIA HAVING THE LOW-SULFUR RESERVES. SO MOST OF THE DEMAND IS IN SOUTHERN WEST VIRGINIA BECAUSE OF THE CLEAN AIR ACT, OTHERWISE THE COAL NEEDS TO GO TO PLANTS WITH SCRUBBERS.

ROBINSON - DOES ARCH HAVE LONG TERM PLANS ON RESERVES FOR THIS 15-YEAR PERIOD? IS THERE DATA TO SUPPORT THIS? **EMERSON** - WE DON'T OWN THE LAND, IN MOST CASES WE LEASE. THESE ARE LARGE TRACTS OF



* Northern West Virginia Coal Field only

FIGURE 3.

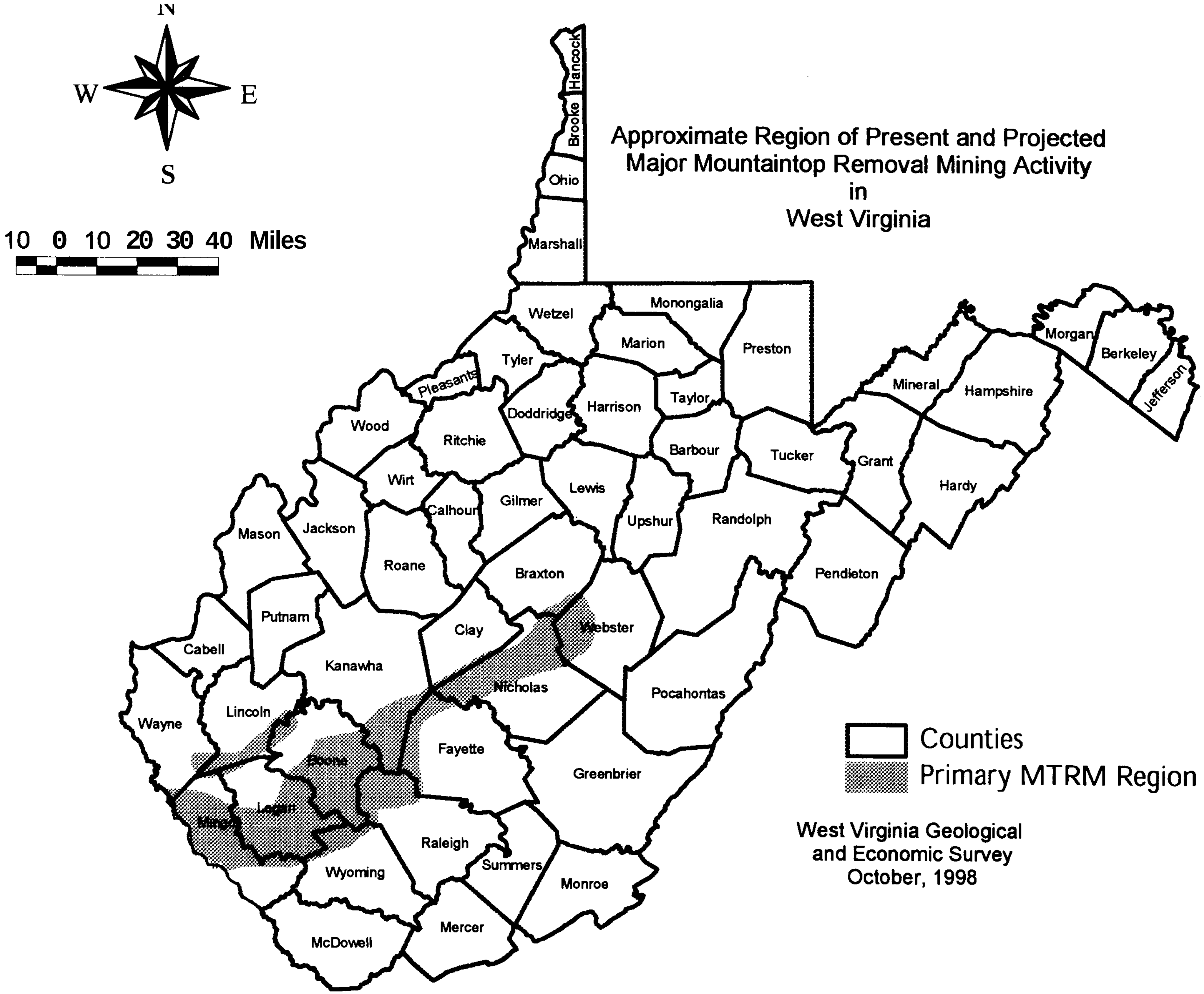

N
W
E
S
10 0 10 20 30 40 Miles
Approximate Region of Present and Projected
Major Mountaintop Removal Mining Activity
in
West Virginia
Hancock
Brooke
Ohio
Marshall
Wetzel
Monongalia
Marion
Preston
Tyler
Pleasants
Wood
Ritchie
Doddridge
Harrison
Taylor
Barbour
Tucker
Mineral
Hampshire
Morgan
Berkeley
Jefferson
Grant
Hardy
Wirt
Calhoun
Gilmer
Lewis
Upshur
Randolph
Mason
Jackson
Roane
Braxton
Pendleton
Putnam
Cabell
Clay
Webster
Kanawha
Nicholas
Pocahontas
Lincoln
Wayne
Boone
Fayette
Greenbrier
Mingo
Logan
Raleigh
Summers
Monroe
Wyoming
Mercer
McDowell
Counties
Primary MTRM Region
West Virginia Geological
and Economic Survey
October, 1998

FIGURE 4.

a

10,000 - 15,000 ACRES. WE HAVE SOME CORE DRILLING DATA ON RESERVES THAT INDICATE 10 TO 15 YEARS OF RESERVES USING LARGE-SCALE EQUIPMENT UNDER PRESENT ECONOMIC CONDITIONS.

POMPONIO - ARE SEAMS BENEATH THE STOCKTON BEING MINED? **EMERSON** - YES, DEEP, CONTOUR AND AUGER MINING ARE ALSO GOING ON.

HARTOS - WHAT TYPE OF SITE CONSTRUCTION CRITERIA GO INTO PLANNING A VALLEY FILL? **EMERSON** - THAT'S A VERY LARGE QUESTION AND WOULD TAKE LOT OF TIME. I COULD IDENTIFY THOSE AREAS FOR YOU LATER.

Dr. Bruce Wallace, Department of Entomology and Institute of Ecology, University of Georgia, Athens, Georgia

The problem here, as I see it, is that it is a difficult question how much headwaters need to be protected to really ensure integrity of downstream reaches (Figure 1). The problem is that we stream ecologists study one or two streams, maybe adjacent waters, or streams in longitudinal linkage. Rarely do we look at drainage networks. I have been working for 28 to 30 years at the Coweeta Natural Research Laboratory in western North Carolina. The Coweeta basin is slightly larger than the controversial Pigeonroost watershed. Over the years we've studied a number of things at Coweeta, such as replacing hardwoods with conifers; we've done some clearcutting experiments to study the response of the stream to clearcutting.

One of the things that I hope to convince you is that there are some things happening in headwater streams that are important, some of the processes there are important, some invertebrates are important and some of the things they do are important. First of all, is the reliance of the stream community on inputs from surrounding forests. One of the ways we've been testing this hypothesis for a number of years is by a litter exclusion project, where we've constructed a canopy over an entire reach of a headwater stream which excludes terrestrial litter inputs so we can see what happens to stream productivity. We also have lateral fences along the sides to keep lateral movement of terrestrial organic matter out of the stream. So we're looking at linkages between invertebrates and what's happening in the stream with detrital inputs from the forest. These detrital inputs are very important to the biology of the stream. The question we're testing is: What happens if this linkage is broken or severely curtailed (we can't eliminate all inputs to the stream). How dependent are these headwater stream invertebrates on detrital inputs? Are detritivores, as a group, food limited (Figure 2).

This slide shows the standing crop of detritus in the stream from the start of treatment (litter exclusion) over 1,460 days (Figure3). The treatment stream has a large amount of stored detritus in it, and has been losing detritus at a rate of about 0.8 grams/m^2/day for the first 4 years of this experiment. So these streams are very retentive, they have a lot of detritus in them and store a lot of material.

This slide shows a reference stream with a lot of leaf material. The next slide shows a litter-exclusion stream, where we've actually excluded the terrestrial inputs to the stream. There's little, in fact hardly any, litter in the stream. We still have large, woody debris in the stream which we removed last summer, so I don't have all those data complete for the past year. However, I do have the results of four years of litter exclusion (Figure 3) which included one year

A difficult question: How much headwaters need to be protected to ensure sustained integrity of downstream reaches?

Stream ecologists primarily study single streams, few streams, or a few streams along a continuum.

How do we incorporate the branching pattern into large-scale patterns and non-linear aspects of the basin?

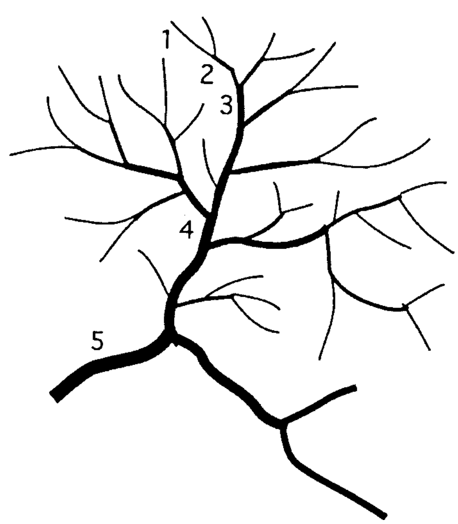
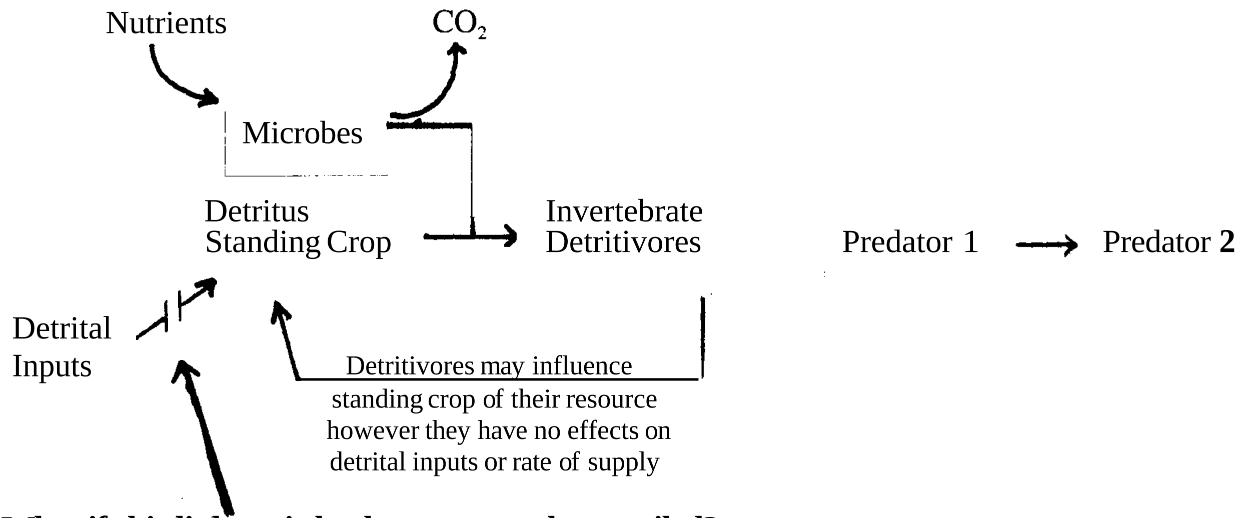


FIGURE 1.



What if this linkage is broken or severely curtailed?
How dependent are headwater stream invertebrates on detrital inputs?
Are detritivores as a group, food limited?
What type(s) of currency do we use to measure invertebrate response?

FIGURE **2.**

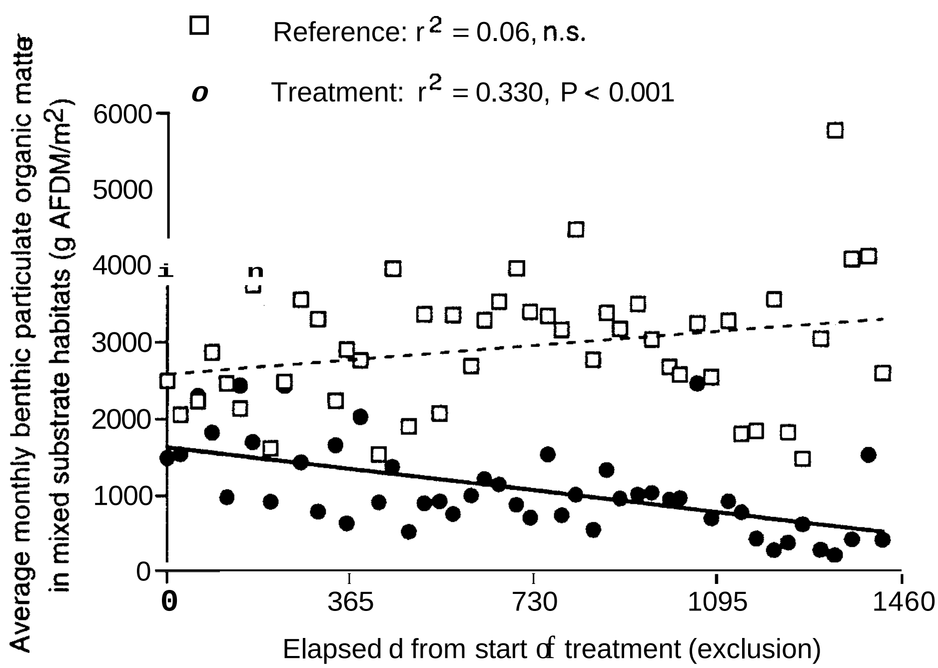


FIGURE 3.

of removal of small woody debris, which decomposes very slowly. What we found was, after we excluded the litter input, that we still had this woody debris which still served as a food resource to certain invertebrates; a few of them were able to switch over to use the biofilm which accumulates on the wood as a food resource.

This slide shows total primary consumer biomass for the first 365 days (pretreatment), during three years of litter exclusion, and during the period of small woody debris removal plus litter exlusion (Figure 4). You can see what's happening to invertebrate biomass: the primary consumer biomass is going down whereas the reference stream biomass remained basically the same. (There was one treatment stream and one reference stream used in this study. We can get away with that by using a randomized intervention analysis technique which uses extensive pretreatment period data compared with post-treatment.)

We also saw a decrease in invertebrate predators and salamanders over time (Figure 5). (There are no fish in these streams; salamanders are the only vertebrate predators.)

I want to point out that there are a couple of functional groups of invertebrates that are very directly dependent on this allocthonous input. One is the shredders, another the gatherers, in fact the primary consumers as a group, invertebrate predators, and this carries all the way up to the salamanders -- significant decreases.

These data are for the mixed substrate habitat, which represents about 87% of the stream area. On the other hand, you have high gradient bedrock substrates, which are dominated primarily by scrapers, filterers, some gatherers, some shredders (Figure **6).** No change in abundance or biomass over time occur on the bedrock habitat, suggesting a somewhat different food web that relies on transported organic matter rather than on material that's actually stored there as benthic organic matter through time.

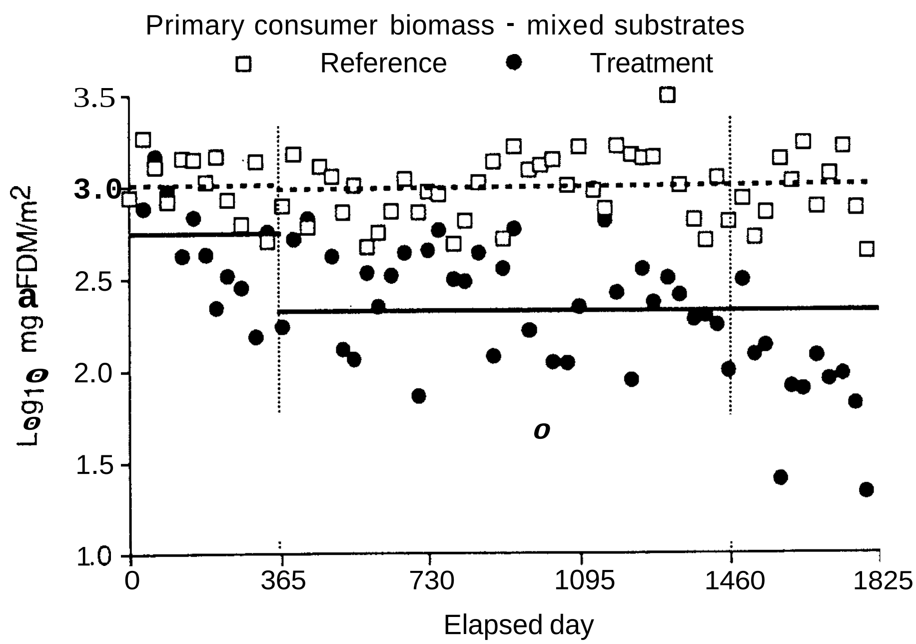


FIGURE 4.

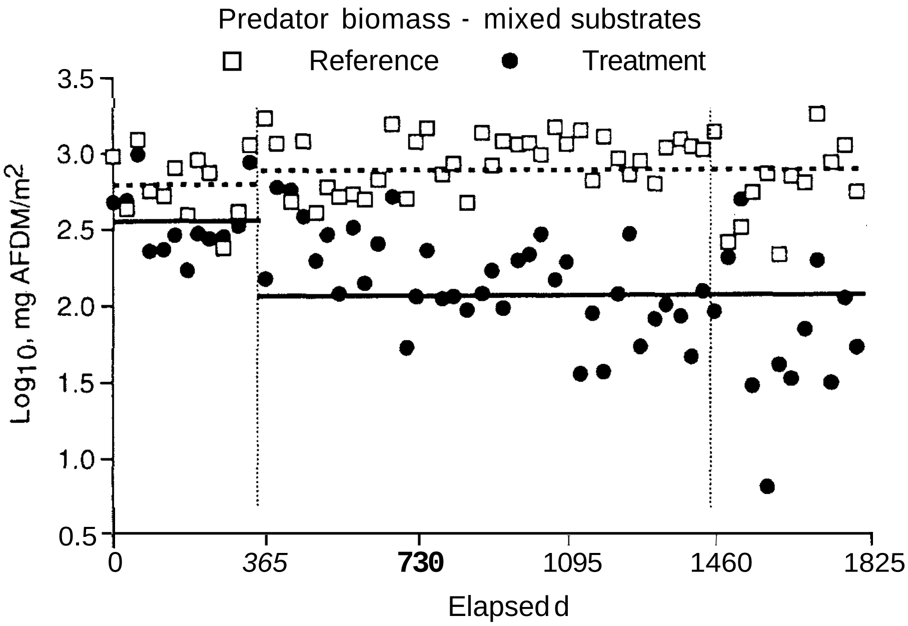


FIGURE 5.

FIGURE 6.

Randomized Intervention Analysis testing probabilities of change between reference and treatment stream for benthic abundance and biomass. Values are probabilities that observed differences were significant.

	-------- Mixed substrates --------		---- Bedrock substrates ----	
Group	- Abundance -	- Biomass -	-Abundance-	- Biomass -
Scrapers	0.408	0.670	0.782	0.822
Shredders	<0.0000001	0.012	0.400	0.574
Gatherers	<0.0000001	0.001	0.752	0.994
Filterers	0.174	0.326	0.227	0.916
Primary consumers	<0.0000001	0.006	0.863	0.612
Invert. Predators	<0.0000001	<0.0000001	0.317	0.399
Salamanders	0.009	0.010	1.000	0.863

We had a period of five pre-treatment years, and if we examine total secondary production vs. predator production in that pre-treatment period, you can still see a relationship (Figure **7).** A lot of that is related to nothing more than the storm hydrograph in a particular year. In those years with many storms, we found that storms remove a lot of leaf material from the stream bed; it's not all exported downstream, but a lot is deposited laterally onto the stream banks, not downstream. Those are years when we see some of the lowest levels of secondary production.

We can show through studies that you can have many anthropogenic disturbances such as clearcutting, fire, agriculture, and mining that disrupt detrital inputs to streams. Assessing the significance for the stream community is difficult in the face of multiple effects that confound the analysis; e.g., with clear-cutting, you can get altered hydrology, altered thermal regimes, enhanced sediment, nutrient and solar inputs, and shifts in the relative importance of detrital inputs and within-stream primary production.

These studies show that litter exclusion alone, without considering the multitude of potential direct and indirect effects, has a profound effect on aquatic productivity. Litter inputs alone influence abundance, biomass, and production of invertebrates. This emphasizes the direct importance of the terrestrial-aquatic ecotones. Therefore, maintaining or reestablishing riparian inputs are an important aspect to consider in the conservation and restoration of streams.

Here's a myth we need to discuss - "Invertebrates and microbiota in these headwater streams represent a minute fraction of living plant and animal biomass (true); therefore, they are not important in the export of organic matter to downstream areas (myth)". We tested this at Coweeta through the application of pesticides to a headwater stream. We found we had to treat seasonally (every 3 months) because there's a lot of recolonization. This slide shows shredder production vs. insecticide treatment (Figure **8).** The pre-treatment production of shredder biomass was 3.5 g/m^2 for the year. Following the first year of insecticide treatment, this dropped to 0.4 g/m^2. Most of the Plectopterans and caddisflies were eliminated. Tipulids are very resistant (you have to kill them with rocks); even with litter exclusion they were the last shredders to leave. They switch over and start eating the wood.

This is a slide of a leaf (Figure 9) that had been fed on by a shredding insect, a peltoperlid stonefly. One of the ways you can follow leaf decomposition in streams is to put known amounts of leaf material in a bag -- coarse-meshed, that allows animals to colonize the leaves. Then you can follow the rate of loss of that leaf litter in the stream through time. We did that in the stream that we treated with insecticide. (We also looked at microbial respiration rate on leaves in insecticide-treated and untreated streams. There was absolutely no difference in microbial respiration; therefore, differences in decomposition of leaves were due strictly to the animal community.) Our results

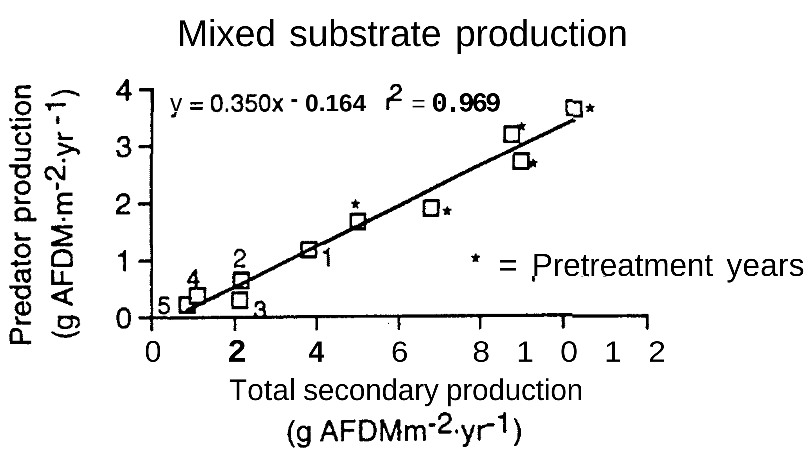


FIGURE 7

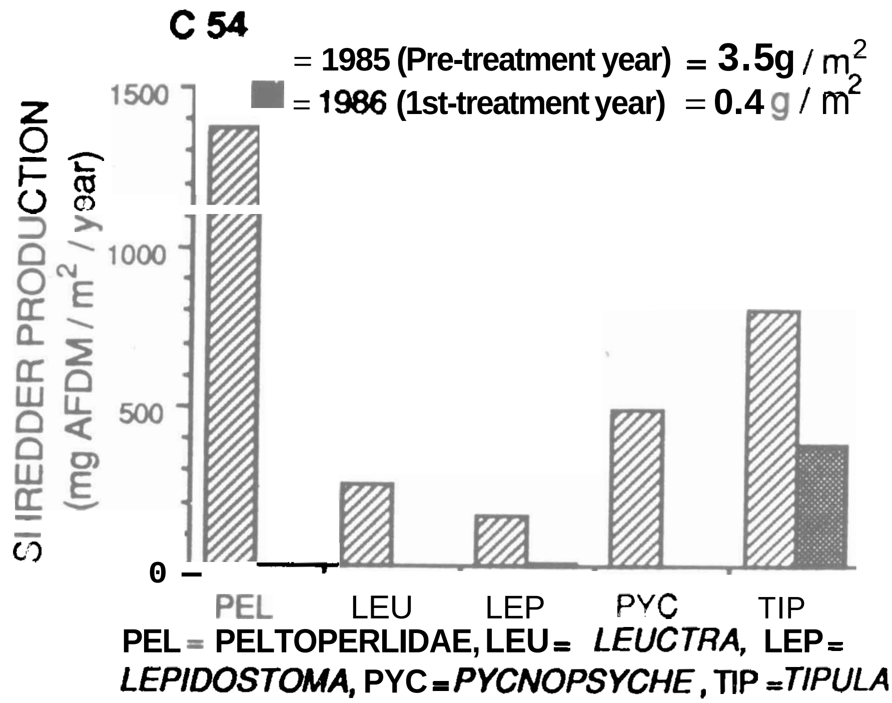


FIGURE 8.

FIGURE 9.

are based on 11 years of data for untreated streams, with 95 to 100 litter bags per year, so this is a pretty extensive study. The average breakdown time for red maple leaves where invertebrates were present (untreated) was 275 days (Figure 10). On the other hand, if you treat and remove most of the invertebrate shredders (with the exception of Tipulids!), you end up with about 575 days. In other words, it takes much longer to break that material down when you remove the invertebrates.

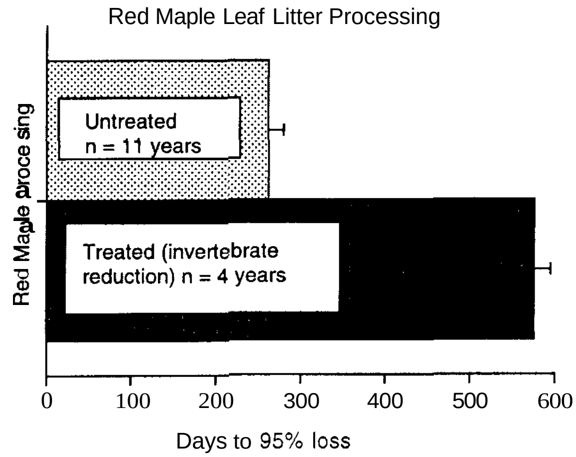


FIGURE 10.

These data show the same for rhododendron (Figure 11). Rhododendron is a thick, leathery leaf, very resistant to decomposition. It takes about 750 days to break down with invertebrates. With removal of large shredding invertebrates, it takes almost 1,800 days. The point is that the invertebrates are very important in the breakdown of some of this material.

Another thing to keep in mind is that invertebrates tend to have very low assimilation efficiencies -- about 90% of everything that enters the anterior end of the body (through the mouth) comes out the rear end as fine particles. In other words, they will assimilate about 10% of material intake and 90% is egested as fine particles. *So* they are actually grinding up this material into small particles which are more amenable for downstream transport. This slide on seston (organic matter suspended in the water column) concentration shows the effect of insecticide treatment (removal of most of the invertebrates) (Figure 12). During a three-year treatment with insecticides, seston was very low. It increased again after treatment ended,. but it took about one year to recover.

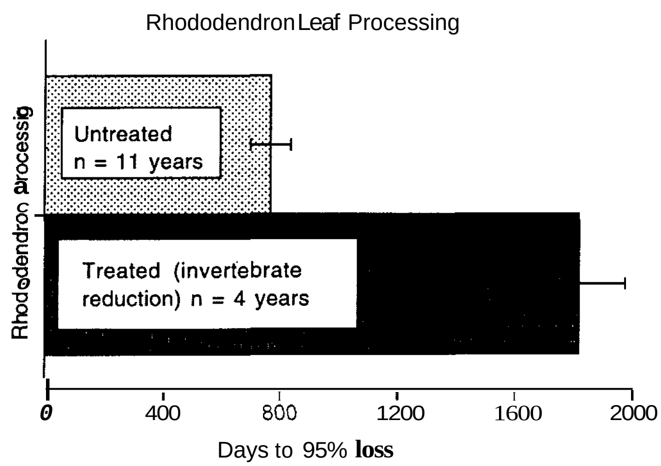
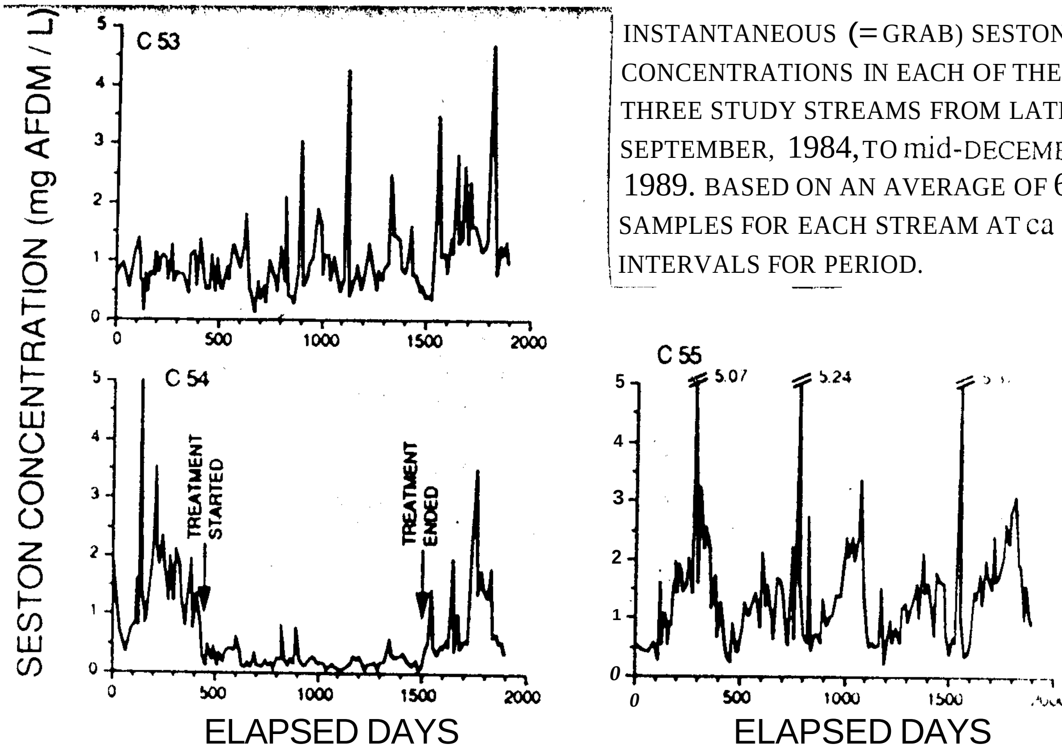


FIGURE 11.

Problem: We know a large amount of export occurs with individual storms. If you do continuous export as opposed to grab samples of export, you will find that continuous export is usually 30 to 40% higher, because with grab samples you're missing the little storm events (Figure 13) that transport much of the organic material. We also know there's a strong relationship between the amount of organic matter exported (coarse particulate organic matter or CPOM, or fine particulate organic matter, or FPOM), with maximum discharge during a given sampling interval. Export of material (Figure 14) is greater with high discharge.

Based on secondary production, the benthic macroinvertebrate production in the insecticide-treated stream was reduced by 1.2 kg/year for the entire stream. Also, the loss of invertebrate production over three years is **3.6** kg. We constructed models of FPOM export, incorporating discharge during each sampling interval, for each of the two reference streams and the treatment stream during the pretreatment year. Based on three-year treatment periods, we saw a reduction of 170-200 kg of FPOM export to downstream reaches in the insecticide-treated stream. With recovery of invertebrate populations (about 1.5 to 2 years), FPOM export approached pre-treatment levels.



INSTANTANEOUS (=GRAB) SESTON CONCENTRATIONS IN EACH OF THE THREE STUDY STREAMS FROM LATE SEPTEMBER, 1984, TO mid-DECEMBER, 1989. BASED ON AN AVERAGE OF 6 SAMPLES FOR EACH STREAM AT ca 2 WK INTERVALS FOR PERIOD.

FIGURE 13

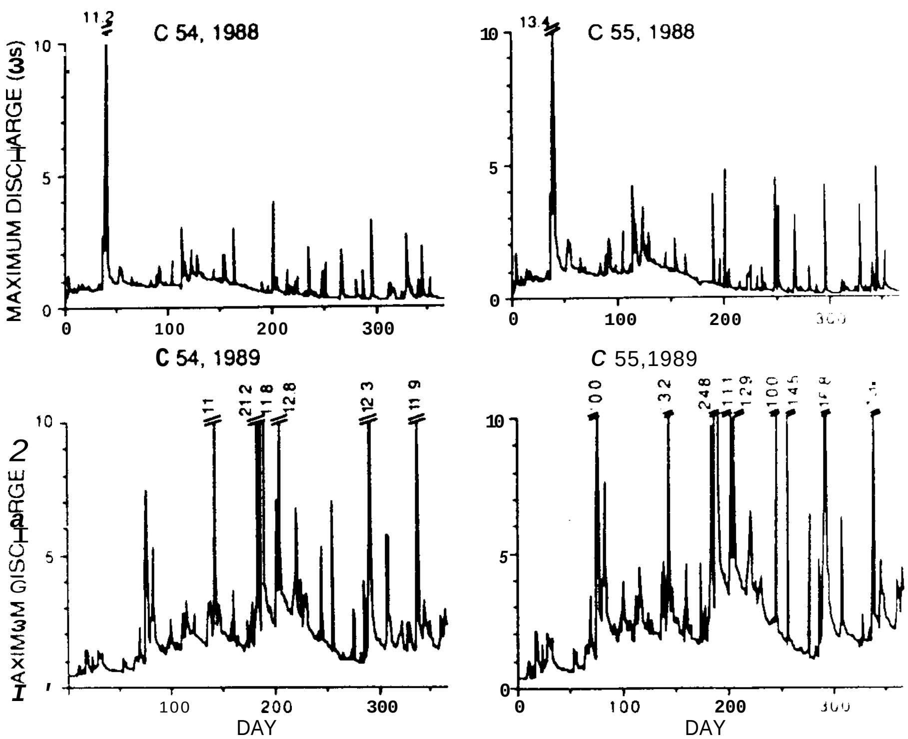


FIGURE 13

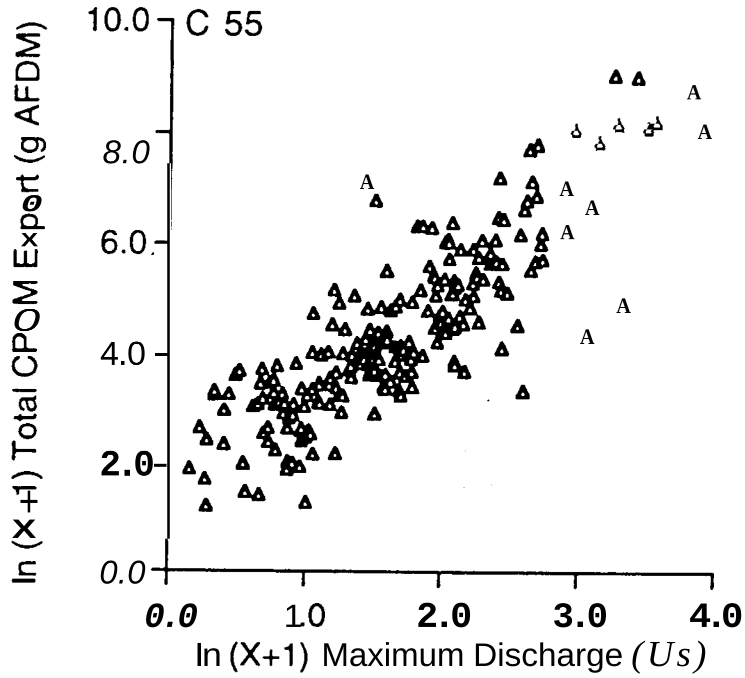


FIGURE 14.

I also want to emphasize that this is invertebrate reduction. and riot complete extirpation, as animals recolonized between treatments or survived treatments. For example:

- Scrapers production reduced by ≈ 71%
- Shredders production reduced by ≈ 88%
- Gatherers production reduced by ≈ 21%
- Filterers production reduced by ≈ 98%
- Predators production reduced by = 71%

So the roles for invertebrates in forested headwater streams are:

a) processing of CPOM to FPOM
b) increase downstream breakdown rates of leaf material
c) enhance downstream transport of organic matter as FPOM is more amenable to downstream transport than CPOM.

Leaves are not very amenable to downstream transport because of high retention of large particles

Here is a quote from a consultant's report: "As a general rule, most small headwater streams have their organic import equal to their organic uptake, allowing the system to exist in a relatively steady stale. The energy used just maintains the status of the existing benthic.; leaving little or no material tot-active transport (as averaged on an annual basis)." I'm riot aware of any stream that works that way. In fact, it would not be a stream if it did.

Example: At Coweeta, Catchment 55, I want to point out that about 80% of the total input of that stream is CPOM from the surrounding forest. You can get about 10% as dissolved organic matter; you get a certain amount of through-fall as well as particulate inputs from the soil, which we have measured. There is very little primary production in these headwater streams as they are usually heavily shaded. The total annual input of organic matter is about 720 g/m^2 or so; keep in mind that 80% is CPOM input, and only 2 to 5% of the output is CPOM (Figure 15). Most of the material, about 56 - 62%, is exported as FPOM, and 30-40% as dissolved organic matter. So, these headwater streams are very important as sites of deposition, transformation, and subsequent export to downstream reaches.

If we look in terms of the total export (in terms of ash-free dry mass, kg/year; Figure 16) (Remember that these are extremely small streams, 0.035 cfs to 0.061 cfs), the total export is 145 - 167 kg/year. Another way to look at this is annual export per m length of stream. We get about 1 kg of export per m length of stream. Looking at total lengths of first and second order streams found in the Coweeta basin, there are about 44.7 km. You can estimate values of the export of this organic matter to downstream reaches: 44 to 45 metric tons, or 50 U.S. tons, per year. And this estimate is low because of underestimation of stream length from maps.

I did a similar analysis for all the streams I could find in the eastern U.S. (Appalachian, ridge and valley, piedmont (White Clay); Figure 17). Note that none of the streams on the slide approach 5 cfs. As you see, by examining total annual organic matter export, with increasing discharge and increasing stream length, there's a general tendency toward more annual organic export per linear m as you go into larger streams. Not surprising -- discharge increases, stream width increases, and stream power increases, but certainly there is this tremendous increase as you go downstream. So headwater streams can be very important sites of organic matter deposition and subsequent export to downstream reaches.

Is this stuff important downstream? You bet. Example: For a fifth order reach of Coweeta Creek, amorphous detritus makes up the large portion of flow of food through different groups of aquatic invertebrates (Figure 18).

Some other concerns from the point of view of stream ecologist: We are seeing increased nitrogen deposition in eastern North America (Figure 19); it's a major problem in some of the forests. What's happening to nitrate concentrations in streams coming out of valley fills, where you no longer have some of these forest activities and microbial populations that might be playing a very important role in the nitrogen cycle?

Annual sources and input (g m^{-2} yr^{-1}) of organic matter to the stream draining Catchment 55 at Coweeta (prior to litter exclusion).

Allochthonous sources	**g m^{-2} yr^{-1}**	**% of total**
Direct fall[1]	492	68.6 %
Lateral movement'	137	19.1%
Dissolved organic matter ([DOM] soil water)	62*	8.6%
Throughfall (DOM) ≈	16*	2.2%
Particulate input from soil ≈	4*	0.5%
Total allochthonous =	**711**	**99.2%**
Autochthonous sources		
Primary production (algae) ≈	3.8	
Aquatic moss ≈	2	
Total autochthonous =	**5.8**	**0.8%**
Total annual input =	716.8	

[1] primarily leaves and woody debris
* inputs not curtailed by litter exclusion, in addition the efficiency of exclusion of the direct fall canopy and lateral movement fence was = 95%.

FIGURE 15.

How much organic matter is exported from forested headwater streams in the southern Appalachians? Data are based on 9-y of continuous measurements at the Coweeta Hydrologic Laboratory in western North Carolina.

	WS 53 Reference	WS 55 Reference
Watershed area ha (acres)	5.2 (12.9)	7.5 (18.6)
Stream length (m)	145	170
Avg. discharge L/s (CFS)	1.06 (0.035)	1.72 (0.061)
Annual range (L/s)[a]	0.33 to 1.56	0.52 to 2.48
Years of data	9	9
Export mg AFDM/L (total)	4.358	4.06
CPOM (% of total expt.)	0.106 (2.4%)	0.159 (5.2%)
FPOM (% of total expt.)	2.452 (56.3%)	1.904 (61.7%)
DOM[b] (% of total expt.)	1.800 (41.3%)	1.023 (33.9%)
Avg. export (g AFDM/d)	399.1	458.6
Export (kg AFDM/y)	145.7	167.4
Annual export (kg AFDM) per m length of stream	1.004	0.985
1st - 2nd order streams (m)[c]	44,700	44,700
Total estimated annual organic export (kg AFDM/y)	44,979	44,030
Export (metric tons/y)	~ 45	~ 44
Export (U.S. Tons/y)	~ 49.6	~ 48

[a] Includes record drought and wet years (65 years of record)
[b] DOM = assumes dissolved organic carbon (DOC) = 50% of DOM
[c] Includes a conservative measure of only total length of 1st and 2nd order streams in Ball Creek and Shope Fork Basins (1,483 ha or 3,673 acres) and does not include an additional 11 km of 3rd and 4th order streams,

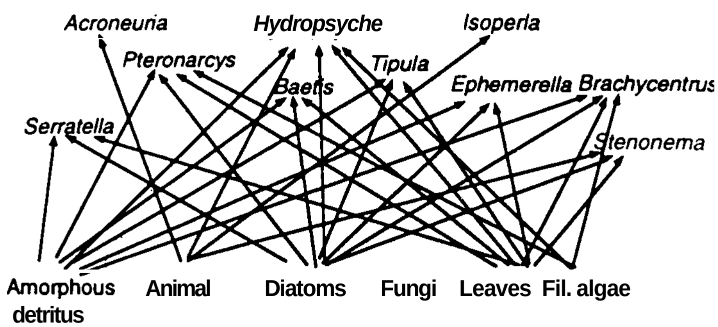
FIGURE 16.

What are some other measures of export per length of stream channel in eastern North American Streams?

Stream and Location	Physiographic Region	Avg. Annual Flow US (CFS)	Stream Order	Total Annual Organic Export (kg AFDM)	Annual Organic export (kg/linear m)
Catchment 53, NC	Appalachian	1.1 (0.04)	1st	399	1.0
Satellite Branch, NC [a]	Appalachian	1.7 (0.06)	1st	459	0.99
Walker Branch, TN [b]	Ridge & Valley	12 (0.43)	1st	2,010	5.9
Hugh White Creek, NC [c]	Appalachian	19 (0.67)	2nd	6,122	5.4
White Clay Creek, PA [d]	Piedmont	115 (4.06)	3rd	83,200	6.6

Sources: [a] Wallace et at. (1997); [b] Mulholland (1997); [c] Webster et al. (1997); and [d] Newbold et al. (1997) *in:* Webster, J. R., and J. L. Meyer (editors). 1997. Stream organic matter budgets: Journal of the North American Benthological Society 16:3-161.

FIGURE 17



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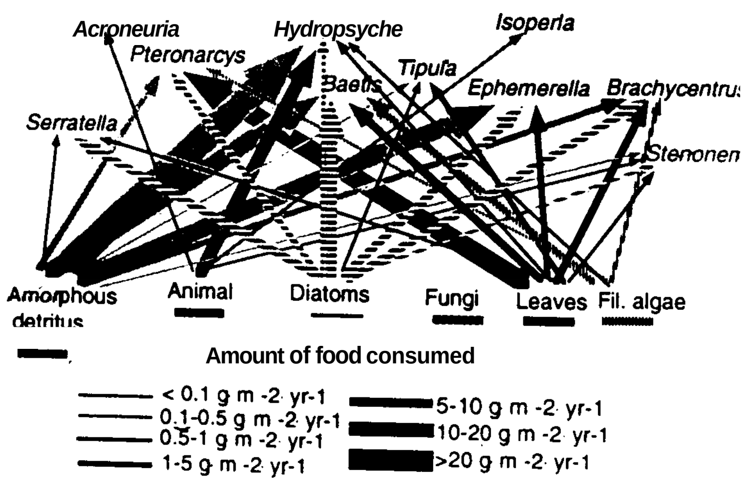
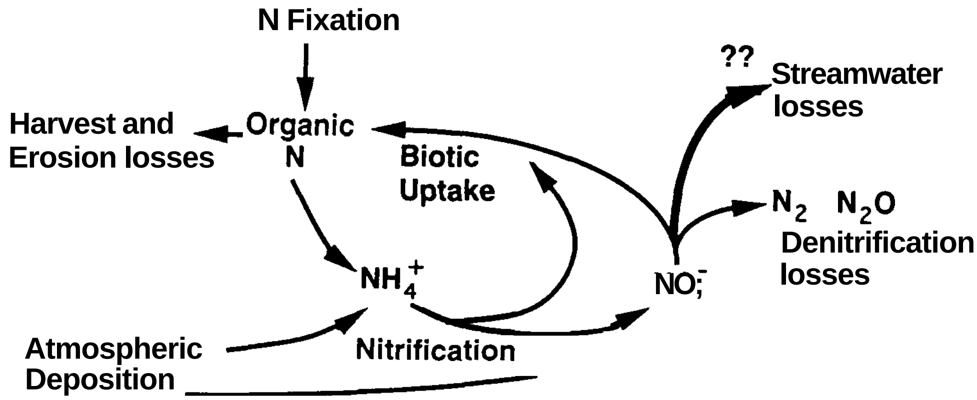


FIGURE 18.



Primarily as a consequence of fossil fuel combustion, nitrogen deposition is increasing in much of eastern North America.

- Biotic uptake by vegetation, transformation by microbes in soils, riparian zones and streams, especially in the presence of available carbon are important mechanisms controlling the export of nitrogen from watersheds.
- How does mountain top removal and valley filling influence downstream nitrate concentrations?

FIGURE 19.

Another myth is that only flows greater than 5 cfs are streams. Only a lawyer would debate this question. How much is 5 cfs? - over 1 billion gallons of water per year. The average city in the **U.S.** uses 100 gal/day/per capita for personal use. In other words, if you looked at this in terms of how many people's water needs this could supply in a year, it's 32,300 people. Or, it would supply the personal and industrial needs of 16,000 people. If you could sell this water in Saudi Arabia, you'd be well off!

Another important point of concern: Stream thermal regimes can have important effects on microbial activity, invertebrate fauna, and fish. For example, for invertebrates these effects include eggs, larval growth, life histories, and seasonal cycles. What are the effects of valley fills and sediment ponds at the base of valley fills on downstream temperature regimes with respect to annual degree days, daily max-min (diel fluctuation), or seasonal temperature patterns? These things have a very important influence on the life cycles of aquatic insects.

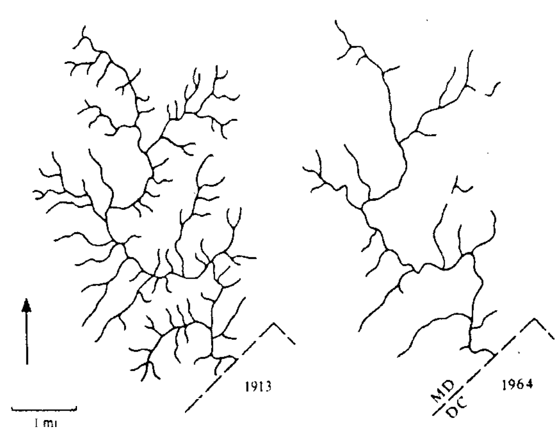
Another myth - There are so many kilometers of first order streams in Appalachia that destroying a small portion does not represent any potential threat to biodiversity. In fact if you look at papers by Morse, Stark and McCafferty - they make a point that the southern Appalachian region and the Appalachians in general are regions of outstanding biodiversity. Morse et al. (1997) consider 19 species of mayflies, seven species of dragonflies, 17 species of stoneflies, and **38** species of caddisflies to be vulnerable to extirpation at present in the southern Appalachians. They suspect the numbers may be considerably higher than these; why? Many of the rare species are known from only one or two locations in springbrooks or seepage areas. Furthermore, many small streams, seeps, and springbrooks have been poorly explored. To add to the problem, immature (aquatic) stages usually cannot be readily identified to species; adult (aerial-terrestrial) males are often required for accurate identification. There are few taxonomic specialists for various groups. Knowledge of their distribution, ecology, life history, and habitat requirements is sorely lacking.

As a closing thought to this biodiversity question, especially because of the potential importance of small springbrooks and spring seeps to southern Appalachian biodiversity, I would like to leave you with a question: Can we continue to destroy and entomb, forever, potential important habitats for life on this planet -- without requiring extensive pre-impact inventories by competent biologists? I think it's a very dangerous thing for life on this planet to do that, and to destroy streams where there is no complete biotic inventory.

I realize that valley fills by coal mining is not the only process that eliminates streams. This overhead shows the effect of urbanization on Rock Creek in Washington, D.C., 1913 to 1964, as you vary and extirpate first and second order streams (Figure 20). We need to be considering some of the hydrologic consequences downstream. It's not fair to equate these [valley fills] to what happens with urbanization, but with Rock Creek, the creek became muddy and silty, there was an increase in annual flood frequency (it's increased 10 to 20 times since about 1913), and downstream increase in channel width and depth associated with increased peak discharge.

PASSMORE - A LOT OF STREAMS DOWNSTREAM OF VALLEY FILLS HAVE RIPARIAN ZONES, SO LEAF LITTER IS PRESENT IN LOT OF CASES. BECAUSE OF THAT, HOW DO YOU ESTIMATE WHAT'S LOST FROM WHAT'S NO LONGER THERE, HOW IMPORTANT IS THAT FOR THE DOWNSTREAM REACHES, AND HOW DO YOU MEASURE IT? **WALLACE** - IT WOULD DEPEND ON THE SITE, AND YOU NEED TO MEASURE EACH ON ITS OWN, DOWNSTREAM OF WHERE WE'VE BEEN EXCLUDING LEAF LITTER AT COWEETA, WITHIN 100 M WE CAN FIND A FULL COMPLEMENT OF INVERTEBRATES AGAIN. **TIBBOTT** -- MAGGIE, WHAT YOU'RE SAYING IS, WE HAVE TO FIGURE OUT WHAT THE IMPACT IS ON THE DOWNSTREAM AREA FROM THE LOSS OF ALL THOSE TONS OF FINE PARTICULATE ORGANIC MATTER PRODUCTION IN THE BURIED REACH, RIGHT? **PASSMORE** -- WELL, I GUESS YOU'RE MOVING EVERYTHING DOWNSTREAM. **WALLACE** -- WELL, IF YOU MOVE EVERYTHING DOWNSTREAM, OVER THE LONG HAUL YOU GREATLY REDUCE THE AMOUNT OF EXPORT TO DOWNSTREAM REACHES IN TERMS OF PARTICULATE ORGANIC MATTER AND DOM, BUT I HAVE NO DATA ON DISSOLVED ORGANIC MATTER.

HANDEL - TO TIE IN WHAT YOU'VE TALKED ABOUT WITH THE PREVIOUS TALK ABOUT CURRENT PRACTICE AND HOW THESE LANDS ARE REVEGETATED: THE COMMON PRACTICE IS TO REPLACE MATURE HARDWOOD FORESTS WITH GRASSLANDS, WITH AN OCCASIONAL SMALL SEEDLING, AND THIS HAS ENORMOUS IMPACT ON PRIMARY PRODUCTION. AS WE LEARNED AT THE KENTUCKY MEETING SPONSORED BY OSM A FEW WEEKS AGO [THE TECHNICAL INTERACTIVE FORUM ON ENHANCEMENT OF REFORESTATION AT SURFACE COAL MINES, MARCH 23-24,1999, IN FORT MITCHELL, KENTUCKY], THESE LANDS UNDER CURRENT PRACTICE RARELY DEVELOP INTO A FOREST -- THE PRODUCTIVITY RATE IS MUCH, MUCH LOWER BECAUSE OF COMPACTION, ETC. THE LINKS BETWEEN UPLAND PRACTICE AND STREAM BIOTA: SOIL REPLACEMENTS WHICH ARE PUT ON THESE MINES ARE TYPICALLY ENGINEERED FROM SUBSOILS, AND EVEN



Drainage basin of Rock Creek upstream of the District of Columbia in 1913 (left) before extensive urbanization and again in 1964 (right)(USGS, Dept. Interior 1964).

Note extirpation of many first and second order channels.

FIGURE 20.

THOUGH THEY HAVE SOME OF THE IONS THAT ARE APPROPRIATE, PARTICULARLY FOR GRASSLAND GROWTH, THEY LACK SOIL BIOTA WHICH ARE NECESSARY FOR PROCESSING AND FOR BIOTIC PRODUCTION THAT EVENTUALLY GETS DOWN INTO THE STREAM. SO I WOULD HOPE THAT THE APPROPRIATE AGENCIES PAY ATTENTION TO THE QUALITY OF SOIL ABOVE AND BEYOND PH AND CHEMICAL CHARACTERISTICS. YOU'VE CLEARLY SHOWN THAT WITHOUT PROCESSING OF THE ORGANIC PRIMARY PRODUCTIVITY, THE EVENTUAL BIODIVERSITY WILL BE AFFECTED. ALSO, THERE HAVE BEEN MANY ATTEMPTS IN RESTORATION OF COMMUNITIES NEAR STREAMS. IT'S BEEN SHOWN WITH SOME WONDERFUL STUDIES THAT THE KIND OF VEGETATION PUT NEAR STREAMS -- WETLAND SHRUBS AND HERBS -- REALLY AFFECTS THE KINDS OF ORGANISMS THAT LIVE IN THE STREAMS. EVEN THE SPECIES OF WILLOW THAT WILL GROW NEXT TO THE STREAM AND WHEN THEY LEAF OUT WHAT KIND OF INSECTS LIVE ON ITS NEW LEAVES AFFECTS THE FOOD WEB FURTHER ON. SO THERE'S A TREMENDOUS AMOUNT OF SUBTLETY ABOVE AND BEYOND JUST HOW MUCH PRIMARY PRODUCTIVITY IS THERE. ARE THERE ORGANISMS IN THE SOIL THAT CAN ILLUMINATE A TRUE BIODIVERSITY IN THIS REGIONAL AREA?

WALLACE (TO HANDEL) - ANOTHER POINT OF CONCERN -- DO YOU HAVE ANY FEEL, AS A TERRESTRIAL ECOLOGIST, FOR WHAT'S HAPPENING WITH NITROGEN? HANDEL - THE BEST STUDIES ARE IN WATERSHEDS THAT ARE HIGHLY DISRUPTED. I BELIEVE CLEARCUTS ARE MUCH MORE BENIGN THAN 5,000 ACRES OF SURFACE-MINED LAND, IN THE SENSE THAT SOIL STRUCTURE IN A CLEARCUT IS RELATIVELY UNIMPACTED COMPARED TO ENGINEERING A WHOLE BASIN. WALLACE - CLEARCUTTING IN COWEETA SAW INCREASES IN NITROGEN FOR A COUPLE OF YEARS, UNTIL REGROWTH, SO YOU HAVE NITROGEN UPTAKE WITH NEW GROWTH; BUT I HAVE NO IDEA WHAT'S HAPPENING WITH VALLEY FILLS; I HAVEN'T SEEN THE DATA. HANDEL - BASED ON INFORMATION IN THE FORT MITCHELL SYMPOSIUM, PRE-SMCRA PRACTICES MAY BE MORE EFFECTIVE FOR NATURAL REINVASION. BUT MOST OF THE NATURAL REINVASION WAS ON THE EDGES, WITHIN 100 YARDS OF THE EDGE - IT'S VERY UNCLEAR WHAT'S HAPPENING MORE TOWARDS THE CENTER OF VERY LARGE, ENGINEERED SITES.

HARTOS - HOW ACTIVE ARE BENTHIC CRITTERS IN EPHEMERAL OR INTERMITTENT PARTS OF STREAMS? WALLACE - I WOULD QUESTION, LOOKING AT SOME OF THESE THINGS THAT ARE CALLED "INTERMITTENT," LOOKING AT WHAT THEY'VE DONE WITH SOME OF THE PIGEONROOST SURVEYS. THE FAUNA THERE ARE VERY SIMILAR TO WHAT WE HAVE AT COWEETA. THESE AREN'T WHAT I'D CALL INTERMITTENT TAXA; THEY HAVE LIFE CYCLES IN SOME CASES THAT ARE UP TO 18 MONTHS OR LONGER, WHICH SUGGESTS THAT THERE'S WATER THERE FOR AT LEAST 18 MONTHS, OR THEY WOULDN'T BE THERE. HARTOS - SO THE LIMITING FACTOR ISN'T WATER, SO LONG AS THEY CAN BE INUNDATED AT CERTAIN PARTS OF THE YEAR? WALLACE - NO, THEY NEED CONTINUOUS WATER.

POMPONIO - YOU'VE DONE A GREAT JOB OF EXPLAINING THE PROCESSES, ETC. MY PROBLEM IS YOU DON'T GO FROM BUGS TO FISH. WALLACE - IT'S OBVIOUS! I CAN GO ON DOWN TO THE LITTLE TENNESSEE RIVER, DOWNSTREAM OF COWEETA, AND SHOW THAT 60% OF THE TOTAL INVERTEBRATE CONSUMPTION IS ATTRIBUTED TO AMORPHOUS DETRITUS (Q - WHAT'S AMORPHOUS DETRITUS? WALLACE - ORGANIC MATTER OF UNRECOGNIZABLE ORIGIN -- OFTEN HAS MICROBES ASSOCIATED WITH IT; MAY HAVE BEEN LEAF MATERIAL, ALGAL, WOOD, ETC.). A LARGE PORTION OF THE LITTLE TENNESSEE RIVER BUG PRODUCTION IS MADE UP OF AMORPHOUS DETRITUS. IT'S ONE OF THE MOST PRODUCTIVE LOCATIONS I'VE SEEN FOR A LARGE RIVER ANYWHERE IN THE WORLD. IT ALSO HAS 44 SPECIES OF FISH, A VERY PRODUCTIVE FISH COMMUNITY, INCLUDING A RIVER REDHORSE THAT'S THE LARGEST NEW SPECIES OF FISH DESCRIBED IN RECENT YEARS FROM NORTH AMERICA. POMPONIO - ....FEEDING OFF THE BUG COMMUNITY PRODUCED BY THE AMORPHOUS DETRITUS? WALLACE - YES. POMPONIO - THAT'S THE WHOLE THING!

KINKAID - IS IT YOUR SENSE THAT AS MATERIALS EVOLVE TOWARDS SOILS, ORGANIC MATERIALS WOULD BUILD UP? WALLACE - AS HANDEL JUST SAID, THERE'S VERY LITTLE ORGANIC MATTER. KINCAID - AS SOILS FORM AND WEATHER, THEY WILL BECOME INHABITED BY PLANTS AND MICROORGANISMS AND AS THESE MATERIALS BUILD, THEY'LL PROVIDE A SOURCE OF CARBON WHICH CAN INTERACT WITH RAINWATER PERCOLATING THROUGH. MY CONCERN IS THAT THE SAME MECHANISM THAT RESULTS IN THE FORMATION OF KARST TOPOGRAPHY WOULD BE ACTIVE OVER A PERIOD OF TIME, AND THIS IS A PROBLEM THAT NEEDS TO BE ADDRESSED IN TERMS OF STABILITY.

HANDEL - EARLIER, THE IDEA OF CREATING ENGINEERED STREAMS ON TERRACES WAS BROUGHT UP. WHAT MIGHT THE QUALITY OF STREAMS ON TERRACES BE VS. NATURAL? WALLACE - YOU COULD MAKE SOMETHING DIFFERENT; YOU COULD CONSTRUCT A WETLAND THAT WOULD BE DIFFERENT BUT CONSTRUCTING A STREAM, SOMETHING THAT RESEMBLED THE ORIGINAL -- I DON'T SEE IT. HANDEL - THE STRUCTURAL COMPLEXITY IS SO DIFFERENT ...

WALLACE - IT'S NOT GOING TO BE ANYTHING LIKE WHAT YOU STARTED OUT WITH; I'M NOT SURE IT'S FEASIBLE TO EXPECT SOMETHING THAT RESEMBLES THE ORIGINAL STREAM.

HANDEL - WOULD YOU CHARACTERIZE THE BIODIVERSITY OF AN ENGINEERED STREAM ON A MINING SITE COMPARED WITH A FORESTED NATURAL STREAM. WALLACE -- IT WOULD BE VERY DIFFERENT. IT MIGHT BE FAIRLY DIVERSE, BUT IT MIGHT BE EXOTIC SPECIES COMPARED TO WHAT WOULD NORMALLY BE THERE.

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Dr. Bern Sweeney, Stroud Water Research Center, Avondale, Pennsylvania

The Stroud Center has been studying the structure and function of stream ecosystems since 1967. During the first five years after opening its doors, the research team at the Center completed an intensive study of White Clay Creek, a small piedmont stream in a quasi-natural state. From those data, Robin Vannote, the Director and team leader at the time, formulated what has been referred to as the "River Continuum Hypothesis" -- a conceptual model viewing the stream ecosystem as a continuum from the first order headwater streams down through larger order rivers (Figures 1 and 2). One of the important things that impressed the team early on was the relationship between the stream and the terrestrial environment. This slide (Figure **3)** shows leaf litter on a square meter of forest floor; the leaves were taken out of the square meter and weighed, and found to weigh 203 g. Leaf litter blows across the forest floor and into the streams. Because our streams are wet depressions in the landscape, you get a lot more organic matter in the stream than on the terrestrial floor. The leaves tend to accumulate behind things in the stream and don't go far in the stream; what does go far is the processed leaves. This slide (Figure **4)** shows the standing stock of coarse particulate organic matter (CPOM) in a wooded area of our stream. Remember that the forest floor had around 200 g/m^2; in the stream in November we have a standing stock of about 800 to 1,000 g/m^2, about four times more in the stream channel than on forest floor, because as the leaves blow across the forest floor, they hit the stream, and they stay, and they accumulate in the stream channel.

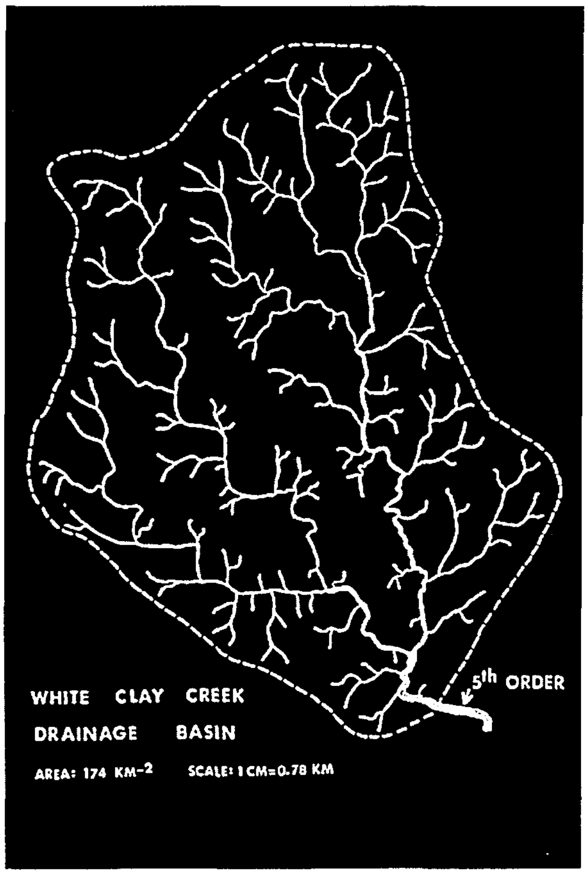


FIGURE 1.

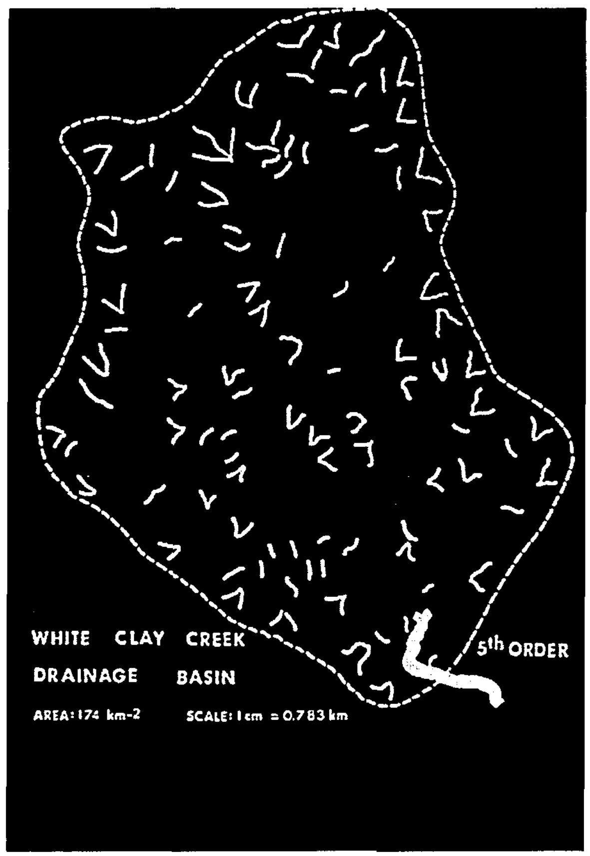


FIGURE **2.** FIRST ORDER STREAMS ONLY.

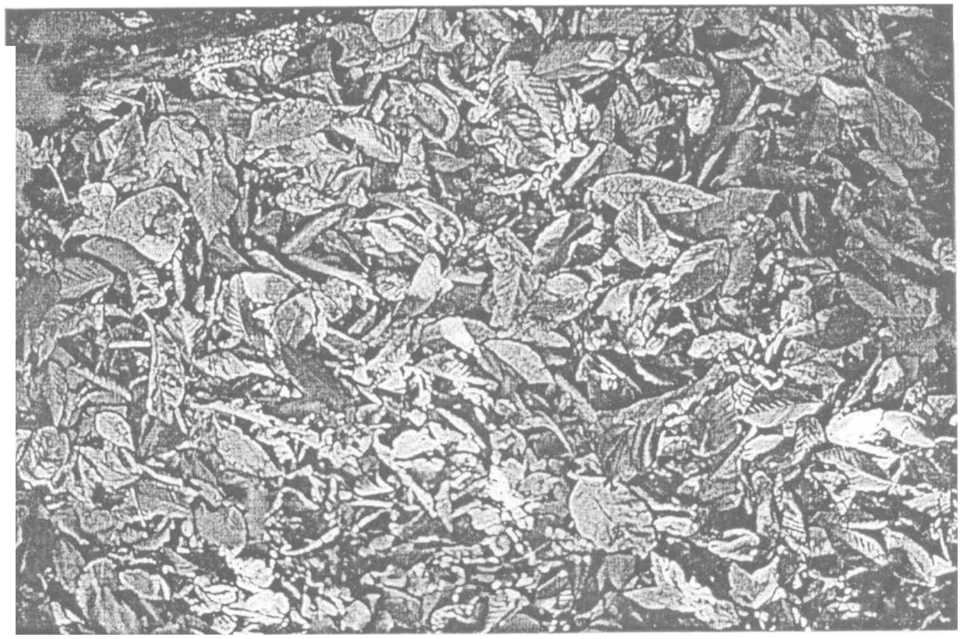


FIGURE 3

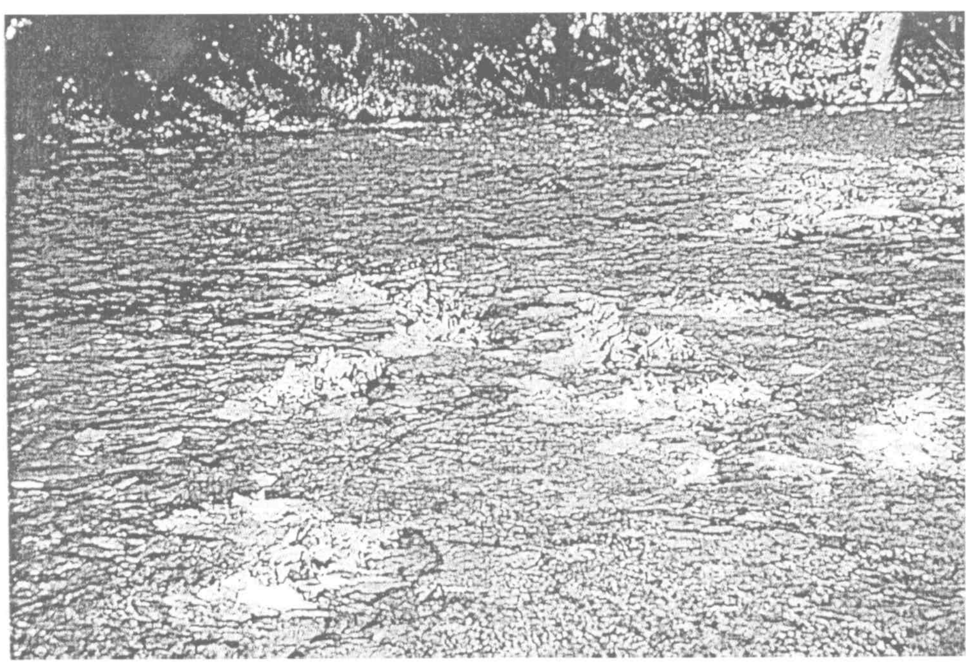


FIGURE 4.

Notice that this stream is flowing [from the forest towards a meadow (no animals in the meadow)] (Figure **5**), and standing stock estimates were made in a downstream direction. The wooded section is very retentive; there is very little export of the coarse leaf litter down to the meadow. ***So*** you have two orders of magnitude lower leaf litter standing stock in the meadow. We just don't get the input of coarse organic matter in our grassy meadows that we do in our wooded areas. This is a concern regarding reconstructing streams in grassy reclamation areas.

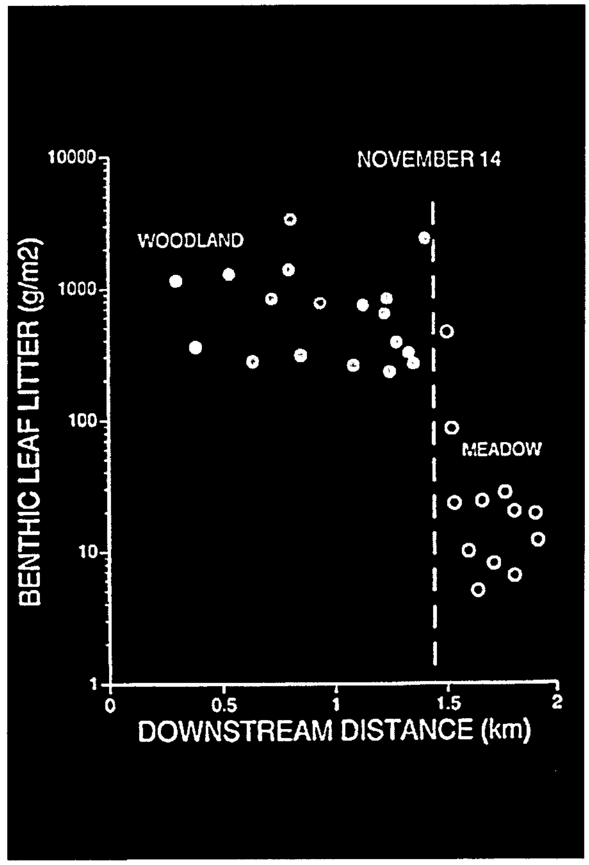


FIGURE 5.

HARTOS - HOW DOES LEAF LITTER CHANGE OVER TIME? **SWEENEY** - THIS TIME OF YEAR (APRIL/MAY) THERE'S VERY LITTLE OF THIS COARSE PARTICULATE ORGANIC MATTER IN THIS WOODED REACH OF STREAM. IT'S ALL BEEN PROCESSED. HARTOS - DOES IT SEEM TO WEIGH OUT WITH THE MEADOW BEING MORE CONSTANT? **SWEENEY** - I DON'T KNOW THAT. BASICALLY, THE PROCESSING OF THIS MATERIAL OCCURS IN THE FALL AND WINTER MONTHS BY INVERTEBRATES; BY THIS TIME YOU'RE LUCKY TO FIND A LEAF PACK, LET ALONE A SINGLE LEAF, IN THE STREAM.

This slide (Figure **6**) shows leaf litter that's been processed by a lot of invertebrates. We measured production in our stream as Wallace did at Coweeta, and got the same kinds of values. We're getting about **5** g/m^2 (dry biomass) for this one species of stonefly on a mixed deciduous diet. We've also done exclusion experiments in our small, first order streams. We've shown that if you change the kind of tree species that go into the first order stream, you can dramatically affect the production and biomass of various invertebrates. For a particular stonefly, with a mixed deciduous leaf diet, we got about **5** g/m^2 of production, but when fed only on red oak leaves in a first order stream, we got only 1 - **2** g/m^2. ***So,*** the type of tree species growing next to these streams is really very critical to many of these invertebrates.

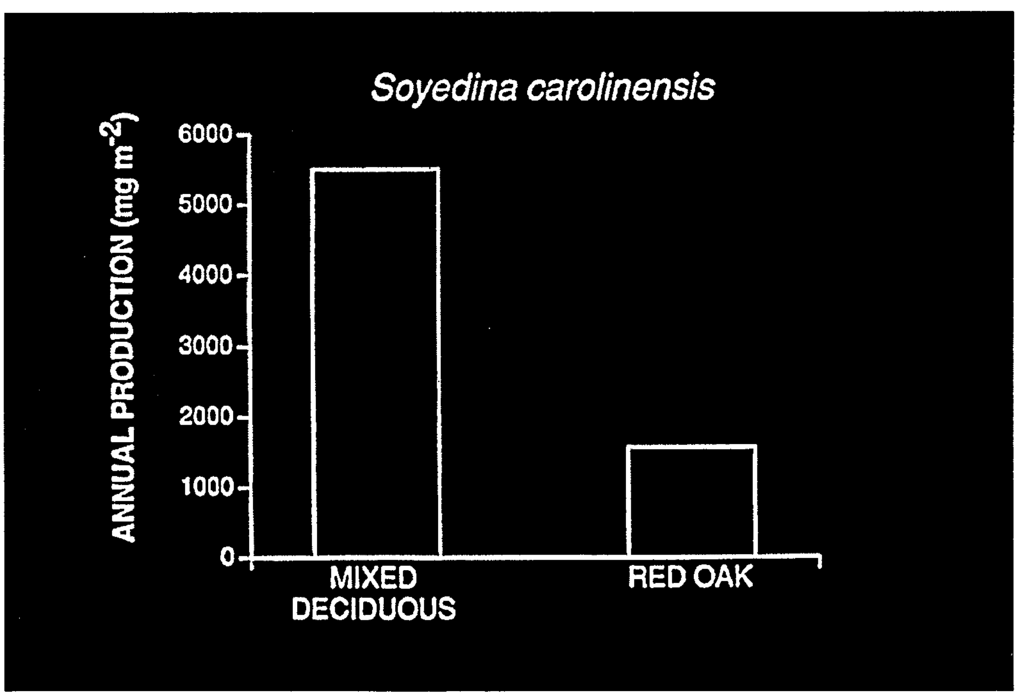


FIGURE **6.**

The next slide (Figure 7) is an analysis of how much area there is in different order streams in our White Clay Creek basin. The slide shows how many streams of each type we have in the basin: 147 first, 47 second, 9 third, 2 fourth. It also shows the average width of the streams in a forested condition, and also the average lengths of tributaries in general in the United States. This is an attempt to try to calculate how much benthic area is available for production for biological and biochemical activities, because in streams a lot of the biological or biochemical action is taking place on the bottom substrates. This is very different than in a lake ecosystem or marine environment where there's a lot of water column processes. In a stream it's on the bottom -- benthos -- that's where the action is. *So* how much benthic area you have per unit length of stream makes a big difference per unit order of stream. You can see from this analysis that about **32%** of total bottom area in our watershed available for macroinvertebrate production or any kind of production is in first order streams; this is a striking thing. First order streams are the heart and soul of a watershed. They're the place where the groundwater interfaces with the surface water. They're the collectors of materials on the landscape. First order streams are scattered all over the landscape. They're the first places where the terrestrial and the aquatic environment interface. **(Q:** HOW DID YOU MEASURE THE WIDTH? **SWEENEY** - THE WIDTHS SHOWN HERE ARE THE AVERAGE BASE-FLOW WETTED PERIMETER OF THE STREAMS.)

WHITE CLAY CREEK

ORDER	NUMBER	WIDTH (M)	LENGTH (M)	AREA (M^2)
1	147	3.0	1,609	704,838 (32.5%)
2	47	3.0	3,701	520,055
3	9	4.9	8,529	369,988
4	2	14.7	19,312	568,545
TOTAL				2,163,426

FIGURE 7.

In our experimental watershed, we have a lot of forest canopy which restricts light levels in the system, but in our first and second order streams we still get some significant primary production going on, because at certain times of year, especially this time of year, before leaf-out, when stream temperatures are high enough, we have enough light levels, we can get significant primary production. We can get up to 100-150 species of diatoms living on the surface of a rock in these smaller streams, tens of thousands of individuals, in this kind of area of stream bottom. Most of these algal species are diatoms because they can live at this time of year and under low light conditions in summer when the trees are shading the stream. This kind of algae is very important in these small-order streams because this was the dominant kind of algae, at least in our area, because it's a shade-loving kind of algae -- it competes well in shaded conditions -- and historically most streams were shaded in our region because it was part of the eastern deciduous forest biome. Consequently, most native species in our small streams that eat algae have mouth parts and digestive systems that are adapted to eating this type of algae (as opposed to filamentous green algae).

This slide (Figure 8) shows some old data (1972-1973) that are some of the first stream metabolism measurements ever made on a stream anywhere. The data are of dissolved oxygen measurements on small-order streams. You can see that in April and May, you have a time where you get a pulse of primary production. During shaded months, the streams are heterotrophic, but in late fall/early winter, when the canopy is gone and you have high sunlight, the temperatures

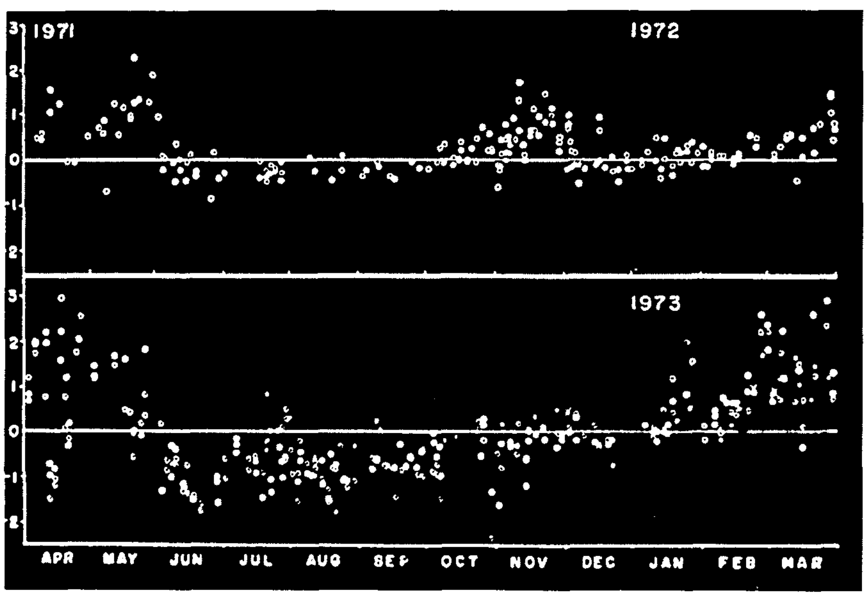


FIGURE **8.**

are suitable and you get more primary production. Consequently, even in these small-order streams, besides the detritivores, you have a lot of herbivores. We have species that go through their life cycles that are timed very specifically to the availability of this primary production. So species like this will put on most of their biomass at a very narrow time of year and it has to coincide with that period of maximum primary production.

The next slide shows again that 203 g of leaf litter on the forest floor. One of the things that was recognized by our organic chemists after the first year or two of study on the White Clay was the importance that this leaf litter plays in the export of dissolved organic carbon to our low-order streams. When rainfall percolates through this leafy matrix on the forest floor, enters the ground as groundwater, and then flows to the stream, it picks up a lot of the organic compounds out of the leaves; at the Stroud Center, we call this "watershed tea." Just like the dark color you get when you steep a tea bag in hot water is the release of dissolved organic compounds that are food -- we drink it as food -- in a watershed, instead of having tea leaves you have hickory leaves, beech leaves etc., but it's the same thing. You have materials coming out of the leaf litter, and the leaves don't have to fall into the stream directly. These compounds go into the groundwater and are carried to the stream by the groundwater. We estimate in our system that this dissolved organic carbon fraction in our low-order streams represents a tremendous piece of the total food pie in the system (Figure 9). This is something which has to be looked at carefully in the mountaintop removal/valley fill situation.

This dissolved organic carbon drives a tremendous amount of productivity in the system. Our microbiologist tells us that in 1 square inch of stream bottom of the White Clay Creek, we have about 6.6 billion bacteria being fed by that dissolved organic carbon, 6 million flagellates (little microscopic animals), and 64,000 ciliates. Of course, this provides the basis for a good part of the food web that in turn gets exported up to larger invertebrates and fish.

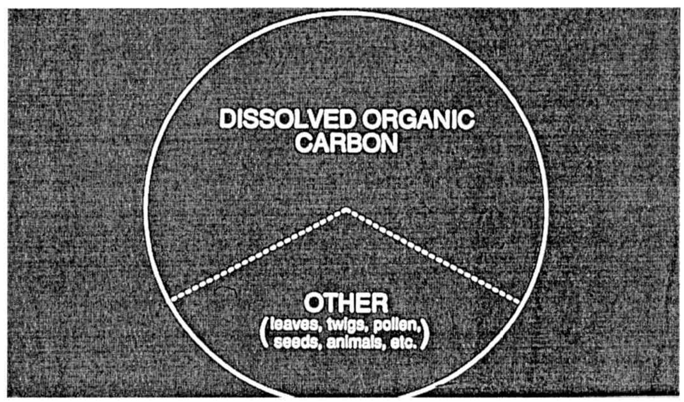


FIGURE 9.

The next slide (Figure 10) shows a schematic of a cross-section through a stream channel to show that streamside areas (wetland areas) along first and second order streams are extremely important not only for the dissolved organic carbon which comes through them, but also because they are zones of nutrient processing. Groundwater brings with it not only dissolved organic carbon, but also nitrogen and other types of nutrients. In our wetland areas, especially the wet soils in first and second order streams, we get a significant amount of denitrification going on. Shallow groundwater is moving through the streamside wetlands and into our streams.

The next slide (Figure 11) shows an analysis of nitrate levels in deep wells, surface springs, in the stream itself, and in shallow streamside wells. You can see that a lot of the nitrogen is being removed in shallow streamside wetland areas before it gets to the stream. This is another issue we've talked about this

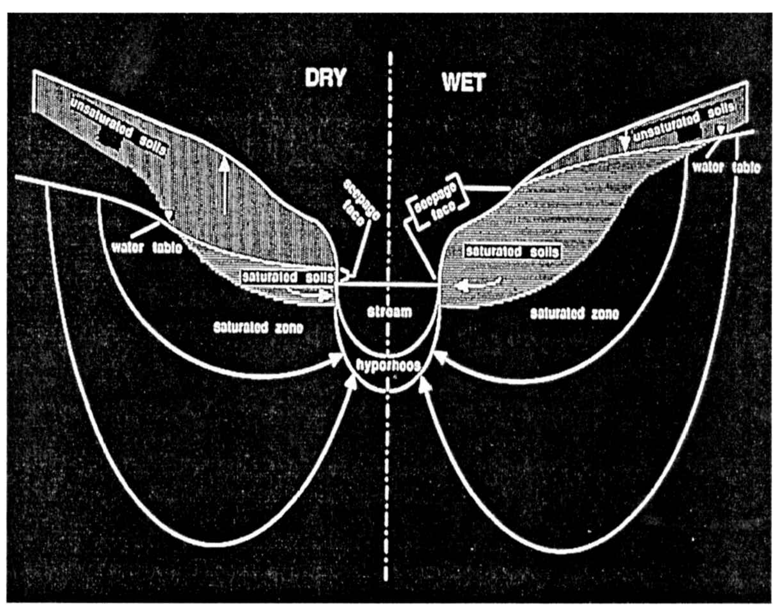
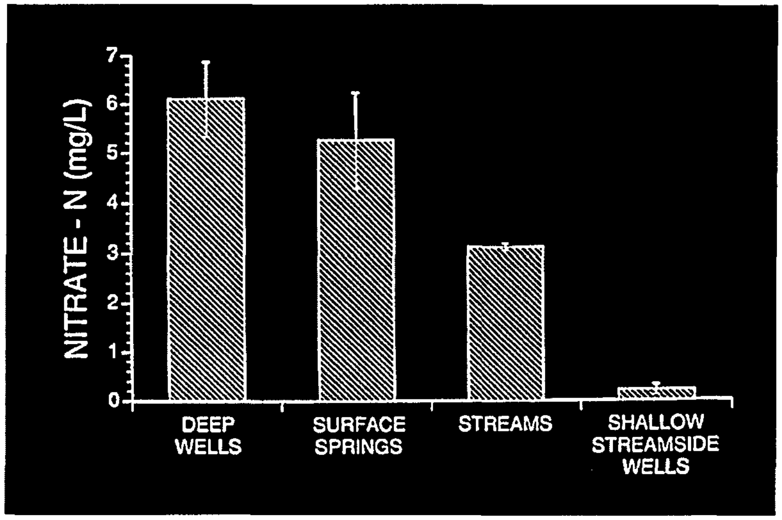


FIGURE 10.



RGURE 11.

morning: How different will these systems be without these kinds of processing areas for nutrients? We certainly have a lot of atmospheric nitrogen loading on our watersheds.

The next slide (Figure **12)** is a schematic illustrating the connectivity between what's going on on the surface with water percolation and the dynamics of small streams. These small first order streams are really tightly connected to what's going on on the landscape through this internal plumbing network.

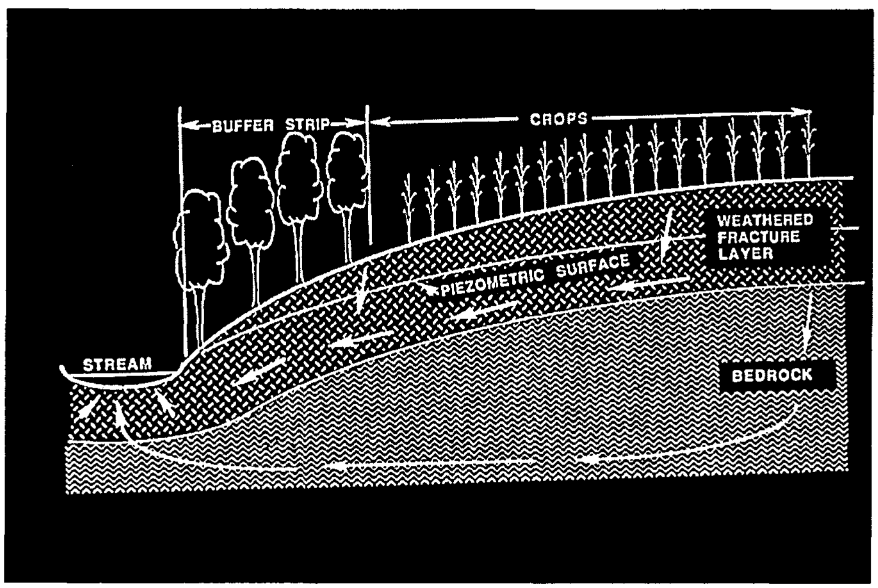


FIGURE 12.

The next point concerns the biota of these systems. The Center has been running Malaise nets which collect adult flying aquatic insects. It's the way that you inventory what species you have there. (You can't tell the species apart from the aquatic larvae for most taxa -- you need to get the adults.) We've been at this for **32** years, and have found up to 304 species in these small streams (Figure **13).** We've done a poor job with dipterans, and I suspect that triple these numbers are really there, and the actual total species number will be over 600 when we're done. So we have a tremendous number of species brought in a very small linear length of stream channel.

The next slide (Figure 14) shows the Breitenback Creek in Germany. They've been working on this stream for about 50 years, and they're up to 881 species of macroinvertebrates. So high species diversity in these small streams is not uncharacteristic -- I think it's the norm.

SPECIES RICHNESS OF AQUATIC INSECTS

Insect Order	White Clay Creek* PA
Odonata (dragon/damselflies)	15
Ephemeroptera (mayflies)	50
Plecoptera (stoneflies)	14
Trichoptera (caddisflies)	52
Megaloptera/Neuroptera (hellgrammites, spongillaflies)	5
Hemiptera (water boatmen,striders)	10
Lepidoptera (aquatic moths)	3
Coleoptera (aquatic beetles)	18
Diptera (midges, craneflies, blackflies)	137
Total	304

* Stroud Water Research Center Survey

FIGURE 13.

BREITENBACH CREEK, GERMANY*

Macroinvertebrates	No. Species	% of Total
Insect	642	73%
Non-Insect*	239	27%
Total	881	100%

* Cited in Allan 1995; non-insect macroinvertebrates include Mollusca, Annelida, Crustacia, Hydracarina, Nematoda

FIGURE 14.

One thing we and others have discovered is that not only do you have high alpha diversity (that is, diversity at a given point in stream, so there's high diversity in first order streams, high diversity in sixth order streams, there's high diversity in the big river) but there's high beta diversity -- the turnover of species as you go down through this river continuum. It's extensive enough that there are very few species that you would find up in the headwaters of a system that also live downstream in the big river -- in fact, I can't even think of any. This is true for invertebrates and somewhat true for fish. My point is there's a continuum of species that have distinct distributions within the river continuum. In other words, a headwater species may only occur in first, second, and third order streams; you don't find it in fifth, sixth or seventh order streams. It doesn't have the right habitat, the right food, whatever. Also, there are species in a big river that you don't find in the headwaters. The point is - what happens when you clip off the top part of this continuum? What happens to a species that happens to only have a distribution in first, second, and third orders? You clip off first and second orders, and you have a much more affected population, restricted only to the third order. How long can that population persist? What happens if there's disturbance in middle of this continuum, say in a third or fourth order stream? What happens to the recolonization process? Are you going to get taxa from downstream going upstream? I don't think so, because organisms in the higher orders probably don't want to live in the lower orders. A lot of third, fourth and fifth order streams are where people like to live and develop the land -- this is where the housing developments are, this is where there's disturbance, and this is where accidents are going to happen -- this is where you'll need recolonization. Recolonization is going to come in from these smaller tributaries, if they exist. We need to think about these things in terms of the persistence of the system as a whole, not just as individual tributaries.

We haven't talked much about densities of invertebrates -- we've talked about production. In this system and others that we've studied, there's a tremendous density of macroinvertebrates and algae on the bottom of the streams. The density isn't really that size dependent. In these small first order streams, we get macroinvertebrate densities of 8,000 - 20,000 individuals per m^2. Down in our bigger watersheds, we get the same densities. ***So*** it's not the case that if you have a bigger stream you have more bugs per unit area. The kind of bugs are very different downstream (species are different), but the densities are pretty equal. ***So,*** a lot of people think of first order streams as a lot of "nothing" -- not much water in them, probably not much living in them. But in fact, the amount of organisms living per unit area is just as much as down in the bigger system. And the fact is that there is so much benthic area in these small streams, and there's so many of them, that collectively a lot of this "nothing" is worth something, and it's something very special -- it's very abundant.

This slide shows a first order stream bordered by grass. We've been studying paired reaches of these low order streams, reaches bordered by forest compared to reaches bordered by grass. In the grass section, the stream is not functionally as well off; the stream is only one-third as wide as the forested reach. A terrestrial forest will shade out grasses; if there is sunlight enough for grasses, they'll put roots in the stream which trap sediments, narrowing the stream bed in two to three years. Because organisms live on the stream bottom, and the productivity and biochemical processing is associated with the bottom area, narrowing will have a tremendous impact on stream productivity.

The last slides show the quality of the populations in a given stream and in broad sense. We have some genetic data published on mayflies in eastern North America. We're one of the few labs to study the genetic structure of aquatic insects. This slide (Figure 15) shows one of the species, which shows very different genes, moving from north to south. These data tell us that there's not a lot of gene flow occurring on a big scale. Gene flow in these insect populations occurs in a stepping stone fashion, as insects fly from one stream to another. What that means is that species like this which are occurring in first and second order streams need to have streams nearby for genetic exchange. ***So*** if there are gaps in the network, what are the implications for gene flow across the whole population? What we don't know may be very important. We don't even know what species are in these first order streams in the area [the mining region] we're talking about. The area of eastern West Virginia/western Virginia is a real hotspot of new species discoveries (Figure 16). It's unusual, non-glaciated, there's been a lot of time for populations to persist and evolve. Thermally, it has lot of diversity. We don't know what's in this area yet, and we don't know its importance to stream ecology.

We can't afford to destroy what we don't know. As a professional who has worked for 30 years in this field, should we be concerned about first and second order streams? We don't draw the line anywhere - we can't sacrifice a single first order stream (Figure 17).

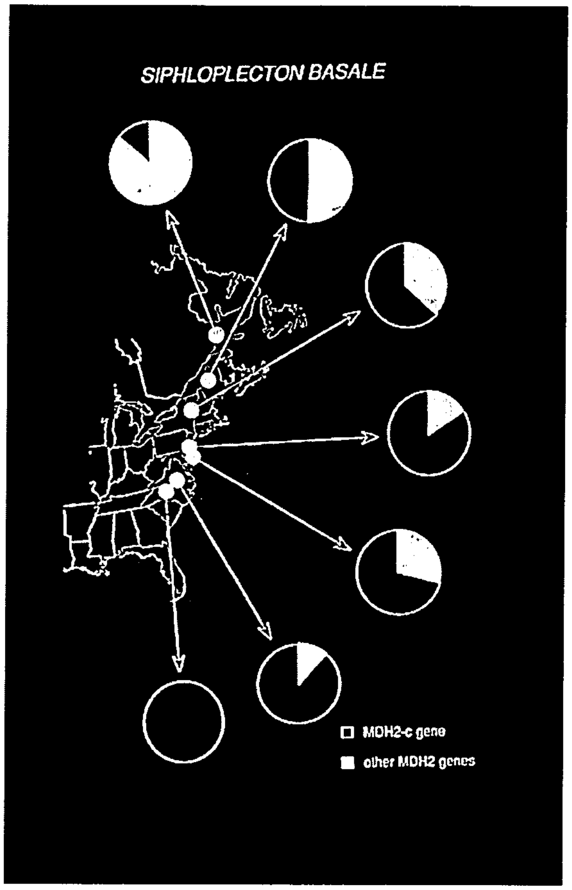


FIGURE 15.

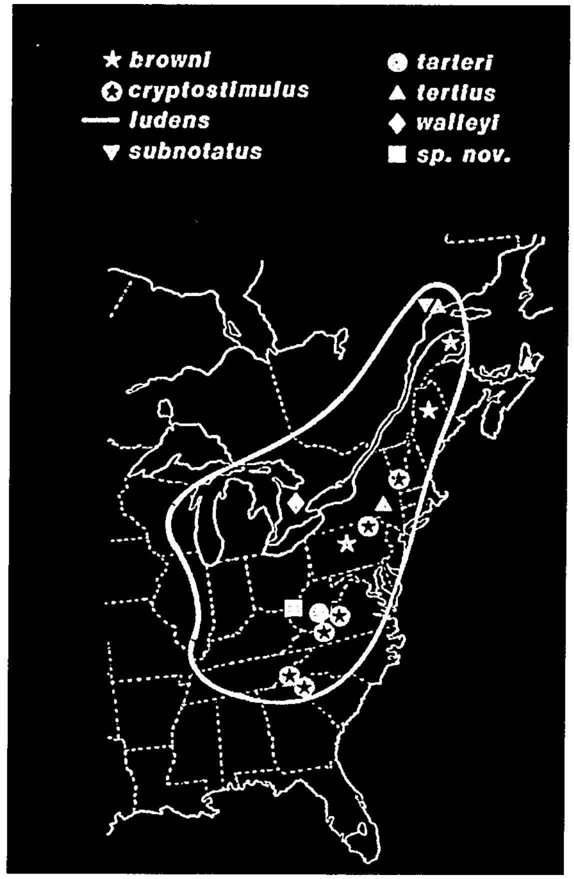


FIGURE 16.

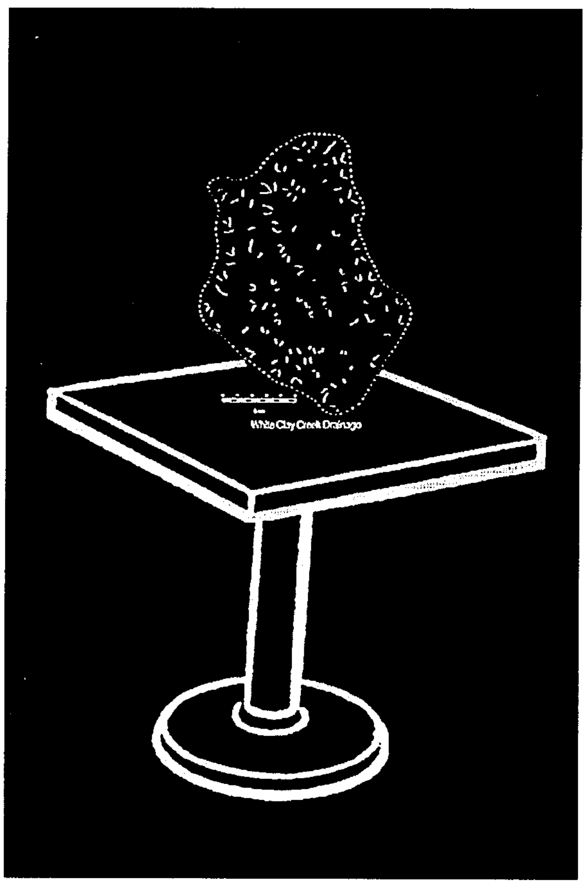


FIGURE 17.

KINCAID - GIVEN THE SHORT TIME FOR EIS STUDIES, AND THE CURRENT DROUGHT SITUATION, DO YOU HAVE ADVICE ON THINGS NOT TO DO? SWEENEY - GO ABOUT DATA COLLECTION VERY CAREFULLY. IF A STREAM IS DRY, DON'T ASSUME NO DATA CAN BE GATHERED. THERE ARE SOME GOOD PAPERS ON THIS REGION AND HOW TO SAMPLE QUANTITATIVELY. I THINK WE HAVE TO RELATE NUMBERS WITH PRODUCTION. YOU ALSO NEED SOME DATA FROM SOME OF THE ALREADY-DISTURBED SITES, SUCH AS THE TEMPERATURE REGIME FROM VALLEY FILLS AND HOW THEY *ARE* LIKE OR DIFFERENT FROM NATURAL STREAMS. TEMPERATURE DRIVES THE LIFE CYCLE OF MANY OF THESE SPECIES; MANY SPECIES HAVE EVOLVED SOPHISTICATED RESPONSES TO TEMPERATURE CHANGES. ALSO CHEMISTRY DATA ON WHAT IS BEING EXPORTED - NITROGEN, DISSOLVED ORGANIC CARBON.

Q: IF ONE WOULD RANDOMLY SAMPLE 20 STREAMS IN AN AREA, HOW DIVERSE DO YOU THINK THESE STREAMS WOULD BE ONE TO ANOTHER? SWEENEY - I'M NOT SURE WE KNOW. THE POTENTIAL IS TREMENDOUS. FOR EXAMPLE, BILL KAUFFMAN HAS DONE STUDIES WITH US IN COSTA RICA ON TWO LOW-ORDER STREAMS THAT ARE SEPARATED FROM EACH OTHER BY ONLY A KILOMETER. IN ONE, THERE WERE 200 SPECIES OF CHIRONOMIDS, IN THE OTHER THERE WERE 200 SPECIES OF CHIRONOMIDS, BUT THE DEGREE OF OVERLAP WAS LESS THAN

50 PERCENT. **Q** - SO THE UNIQUENESS THAT EACH OF THESE STREAMS REPRESENTS IS GOING TO HAVE TO BE ADDRESSED. **SWEENEY** - I THINK SO. THE PROBLEM, THAT I'VE TRIED TO CONVEY AND THAT BRUCE HAS TRIED TO CONVEY, IS THAT IT'S NOT EASY TO DO A TAXONOMIC INVENTORY OF THESE SYSTEMS. BUT JUST BECAUSE SOMETHING ISN'T EASY DOESN'T MEAN THAT IT SHOULDN'T BE DONE, OR THAT YOU SHOULD ALLOW SOMETHING ELSE TO HAPPEN BEFORE IT'S DONE.

POMPONIO - IS THERE ANYTHING IN YOUR STUDIES WHICH HAS LOOKED AT THE USE OF THOSE SYSTEMS BY TERRESTRIAL CRITTERS LIKE BIRDS? **SWEENEY** - YES, WE HAVE SOME DATA ON EXPORT OF AQUATIC LIFE. THE MALAISE TRAPS WOULD GIVE YOU DATA ON WHAT'S EXPORTED. ALSO WE KNOW THAT THERE'S A GREAT DEAL OF INTERACTION BETWEEN BIRDS AND INSECT POPULATIONS IN TERMS OF MAINTAINING SOME OF THE INTEGRITY OF THE LIFE HISTORIES, FOR EXAMPLE, EMERGENT SYNCHRONY. YOU HAVE A SPECIES THAT LIVES IN THE STREAM FOR A WHOLE YEAR, AND THEN ALL OF A SUDDEN IT EMERGES ON APRIL 10, AND ONLY APRIL 10-15 AND REPRODUCES. WHAT MAINTAINS THAT KIND OF SYNCHRONY? WE PUBLISHED INFORMATION SHOWING THAT TERRESTRIAL BIRDS FEEDING ON THE TAIL ENDS OF THE EMERGENCE PERIODS CAN MAINTAIN OR SELECT AGAINST INDIVIDUALS THAT EMERGE TOO EARLY OR TOO LATE. THERE'S A LOT OF THAT KIND OF THING THAT GOES ON. **POMPONIO** - I THINK IT'S IMPORTANT TO FOCUS NOT ONLY ON THE AQUATIC SPECIES, BUT ALSO WHAT'S USING THEM THAT'S AN IMPORTANT PART OF LANDSCAPE -- THE WHOLE INTERACTION. **SWEENEY** - WELL, I CAN TELL YOU THAT WHEN YOU GO OUT COLLECTING EMERGENT MAYFLIES AT CERTAIN TIMES OF THE YEAR, YOU'RE REALLY COMPETING WITH THE BIRDS.

[Note: Dr. Sweeney sent a letter to the Fish and Wildlife Service after the symposium, summarizing many of the points in his presentation. The letter is reproduced on the following pages.]

STROUD WATER RESEARCH CENTER

970 Spencer Road
Avondale, Pennsylvania 19311

Telephone 610-268-2153 610-268-0490 Facsimi

May 11, 1999

Mr. David Densmore
Supervisor
Pennsylvania Field Office
U. S. Fish and Wildlife Service
Suite 322, 315 South Allen Street
Sate College, PA 16801

Dear Mr. Densmore:

One of the key issues with respect to the Mountain Top Mining debate is whether small (first and second order) streams are important and worthy of unconditional protection and preservation? I offer the following thoughts in an attempt to convince you and others associated with the debate that the answer is an emphatic and unqualified **YES!**

The Stroud Water Research Center has been studying the structure and function of small tributaries of the White Clay Creek (WCC) Watershed since 1968. Results from the first few years of study quickly established the tiniest of streams (first order) as being both abundant and crucial to the overall function on the ecosystem. Vannote's "River Continuum Theory," which was first developed out of the early studies on the WCC, made special note of the importance of first order streams and their physical, chemical, and biological connectivity to the larger downstream tributaries.

Numerous studies over the years at the Center have shown that first order streams occur throughout the watershed, interface clearly with the landscape, and are the primary collectors of material and energy for the stream ecosystem. Under natural conditions, small streams receive leaf litter directly from the forest canopy and, because they are wet depressions in the landscape, often trap leaves blowing across the forest floor. Thus, small streams in WCC can have an average 800-1000 g/m^2 standing stock leaf litter in November even though the surrounding forest floor only averages about 200 g/m^2. These leaves are processed (eaten) by a variety of aquatic macroinvertebrate species and converted to animal biomass by some species at a rate of 5-8 $g/m^2/year$. Given that the WCC watershed contains about 147 first order streams which collectively contain about 700,000 m^2 of bottom area for macroinvertebrate production, the amount of animal biomass and smaller particles of food produced from leaf litter processing alone is staggering. Over 32% of the total benthic surface area in WCC is represented by first order streams. This is especially important because most of the structural and functional activity in a stream ecosystem is associated with benthic substrata (bottom areas) as opposed to water column processes.

Although small, natural streams in the WCC often flow through forest, seasonal openings in the canopy (Spring and Fall) and the occurrence of shade tolerant algae (diatoms) enable significant levels of primary production to occur. Studies at the Center have not only documented that each square meter of first order stream bottom is capable of producing significant levels of algae (–0.2 - 0.4 g C m^{-2} d^{-1}), but that individual rocks can often contain over 100 species of algae (diatoms) representing thousands of individuals.

Significant biological productivity in tiny first order streams of WCC is also associated with bacterial communities which are feeding on large amounts of dissolved organic compounds (DOC) carried to the stream by groundwater. The DOC, which effectively can represent up to 60% or more of the total food base of a small stream, originates from rainwater percolating through the organic matter (leaves, twigs, etc.) of the floor of the watershed. A square centimeter of stream bottom substrata in a small tributary of WCC can support a community consisting of about 1 billion bacteria being fed on by 1 million microflagellate and 10,000 ciliated invertebrates --- all supported to a large extent by DOC.

Thus, the in-stream biological productivity of first order streams is significant and certainly non-trivial compared to larger streams. In fact, widely accepted models of ecosystem structure and function (e.g. River Continuum, nutrient spiraling) strongly connect the productivity and structure of downstream communities with their smaller upstream tributaries.

In similar fashion, the chemical fingerprint of downstream reaches is determined in large part by the fingerprint of upstream tributaries. In WCC, for example, the wetland areas adjacent to first order streams are critical areas of denitrification for groundwater flowing into the system. Thus, despite high levels of nitrate in watershed groundwater (e.g. > 5-6 mg/l), nitrate levels in low order streams average < 3 mg/l.

The unique physical, chemical and biological conditions of low order streams supports not only a productive fauna and flora but a high level of diversity. In WCC, well over 300 species of aquatic insects alone co-exist in a small tributary. Both alpha and beta diversity are high in the system. Thus, species occurring in the small tributaries typically do not occur in the larger downstream reaches and vice versa. This means that eliminating first order streams greatly jeopardizes the ability of certain species to maintain local populations and provide propagules for recolonizing disturbed areas. In Appalachian mountain watersheds, the biological diversity of small order streams has not been studied extensively. Recent studies, however, indicate a substantial level of endemism and a disproportionately high level of species new to science associated with these small stream systems.

The abundance and proximity to one another of first order streams have also been shown to have important implications with respect to maintaining levels of genetic diversity in natural populations. For example, a comparison of the genetic structures of certain WCC populations with populations elsewhere (north or south) in their geographic range suggest that gene flow occurs in a "stepping stone" fashion (i.e. occasional short distance migration as opposed to long distance genetic exchange). Elimination of first order steams, or a portion of the "stepping stones", has obvious negative consequences for dispersal and gene flow of species uniquely adapted to these systems.

In conclusion, small first order streams form the heart and soul of the functional stream ecosystem in WCC and every watershed that has been carefully studied. They are small but numerous and collectively represent a significant part of the system with respect to its physical, chemical and biological characteristics. They support a wide variety of unique species that do not occur in larger streams. The structure and function of small streams is not only important locally (to the reach itself) but critical to the productivity of larger downstream tributaries. Clearly, any discussion of destroying even one first order stream is out of order. Rather, first order streams should be placed on a pedestal, protected at all cost, and treated with reverence in the sense of respect co-mingled with awe.

I hope that these comments are helpful to you and your staff.

Sincerely,

Bernard W. Sweeney
Director and Curator

Dr. Denis Newbold, Stroud Water Research Center, Avondale, Pennsylvania

This slide (Figure 1) shows the conceptual diagram of nutrient spiral in the stream. That concept was developed by Jack Webster of VPI, who published it with Bruce Wallace. The spiral tells you how effective the ecosystem is at processing nutrients. The tighter the spiral, the more effectively the ecosystem is trapping and reusing organic matter and nutrients as you go downstream stream. But there's another side of this: The tightness to the spiral which we measure with length (the distance something has to move downstream in order to be processed in some way) (Figure **2).** This spiraling length (or "turnover length" when referring to carbon) has particular relevance to the question we face. If you're sitting in a downstream ecosystem, where did your nutrients come from -- how far upstream did they come from?

The original work on spiraling looked at the cycling of phosphorus. This slide (Figure 3) shows an upstream and a downstream caddisfly. In these original examinations of nutrient cycling, we could see evidence of spiraling taking place: a downstream caddisfly that collects particles in its net is actually getting labeled with radioactive phosphorus relative to the one upstream, providing the evidence that this downstream animal is depending on an upstream source.

I'm going to focus mostly on carbon, and shift to what we've learned in studies of White Clay Creek (but there have been a lot of studies at Coweeta and elsewhere showing similar things). **A** simple carbon cycle here (Figure 4) involves algae on the stream bottom, and/or microbes. **As** microbes decompose organic matter, or as algae produce organic matter through photosynthesis, they release a lot of dissolved organic carbon to the water column, which then moves downstream. Traditionally we viewed the organic matter in the stream, the dissolved organic matter especially, as refractory (i.e., it doesn't get used very fast; it eventually gets to the ocean where it may last a hundred years) (Figure 5). Much of the dissolved organic carbon (DOC) is, in fact, refractory, but there's also a significant labile component to that carbon which cycles within the stream ecosystem.

This slide (Figure **6)** shows dissolved organic carbon cycling in White Clay Creek; it shows the fate of dissolved organic matter (in this case produced by algae, but it would be similar to that produced by microbes decomposing litter that falls into the stream). Based on our experimental results, the labile component of the DOC produced by the algae will travel 2 km downstream before being taken up and utilized by the streambed microbes. The refractory component will travel much farther. The estimate shown here of 144 km actually means that it would travel an average of 144 km downstream if the stream were not to grow any larger. But of course, the stream -- in this case, the White Clay Creek -- does grow larger, and in fact enters the Delaware Estuary in much less than 144 km. Thus, the 144 km actually means that nearly all of the refractory component will reach either the estuary or the ocean before being utilized. These estimates were based on the third order reach of the White Clay, and the 2-km turnover length for the labile DOC is about the same length as the reach. In fact, it turns out that the way these distances scale, the turnover length for labile DOC in a reach of any given order, will be comparable to the average length of a segment of that order (Figure **7).** Thus in a first order reach, which is typically about 1 km long, the turnover length for labile DOC would be about 1 km. This means that we can normally expect about half of the labile DOC produced within any given reach to be utilized within the reach, while the remainder will be passed to a larger downstream reach. The next reach, which is typically second order with a length of 2 to 3 km, will have a proportionately longer turnover length, so the downstream transfer and utilization successively cascades downstream. Each downstream reach will utilize a portion of the labile DOC passed from upstream, and pass the remainder downstream.

The next slide (Figure **8)** emphasizes the production of dissolved organic phosphorous, which has a lot of the same characteristics as dissolved organic matter.

Now **I** want to discuss the transport of fine particulate organic matter, or seston. We've been involved in a number of studies of how particles move downstream through a system. This is a diagram (Figure 9) of how particles might settle and be resuspended in the water column. We put radioactively-labeled particles in streams, along with red dyes to serve as tracers, and then sampled over several months after that in the sediments. From this work you get a picture of how much of these particles that are in the water column are settling, how long they stay on the bottom, and when they come back up, how far downstream they go. In a third order stream (Smiley Creek) in Idaho the

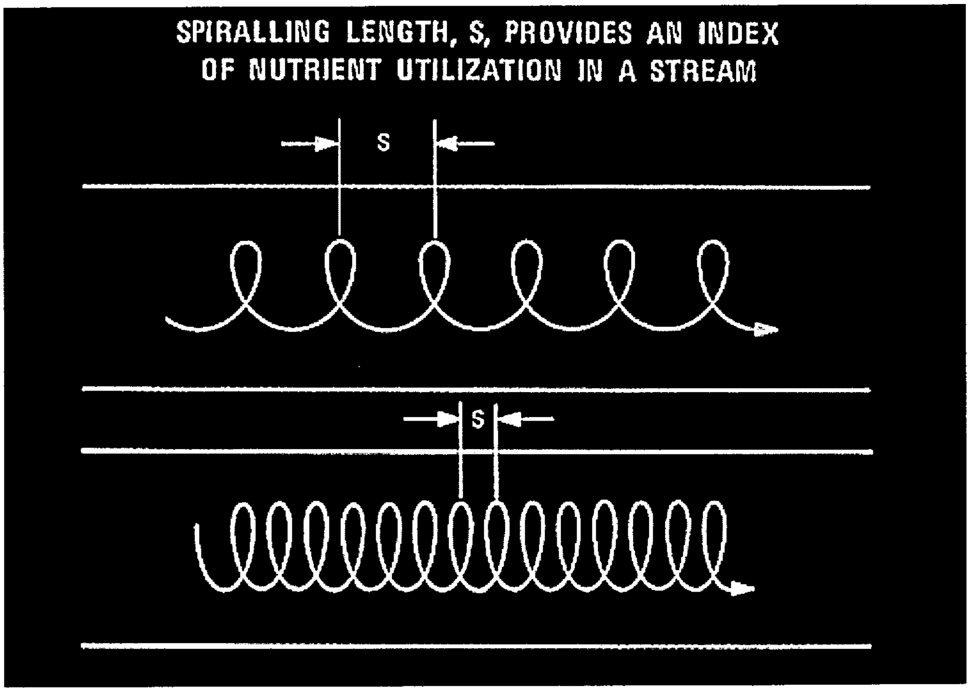


FIGURE 1.

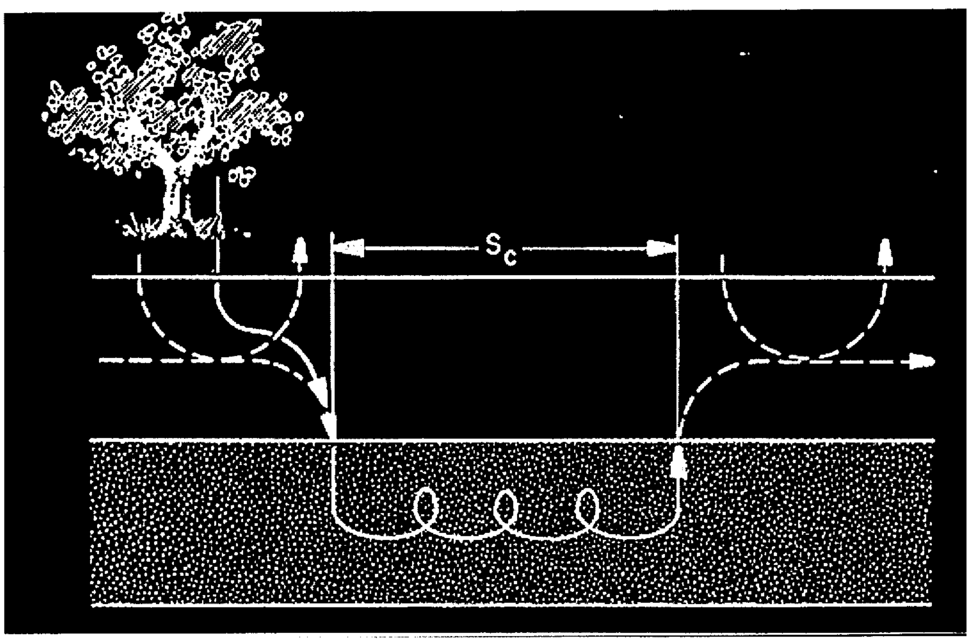


FIGURE 2.

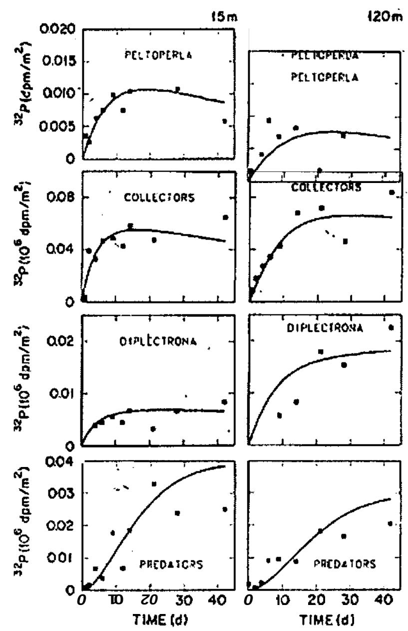


FIGURE 3.

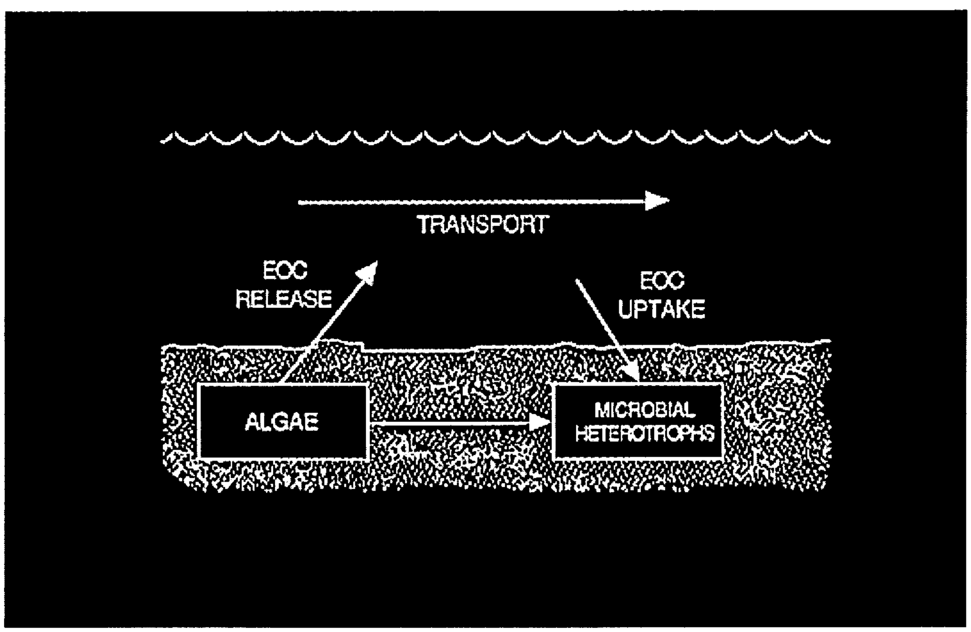


FIGURE 4.

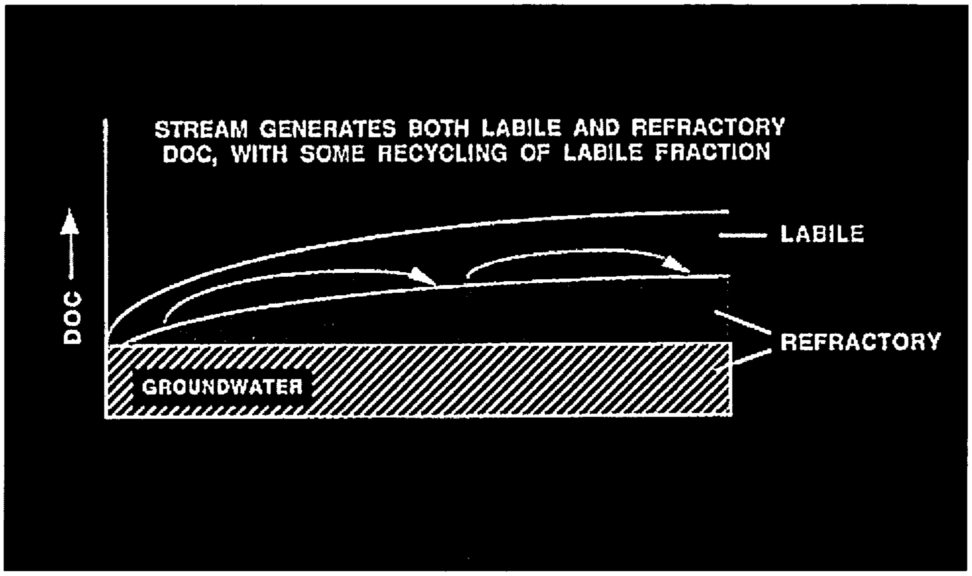


FIGURE 5.

DOC CYCLING IN WHITE CLAY CREEK

THIRD-ORDER REACH:
DEPTH, d = 0.2 m
VELOCITY, v_w = 0.12 m/sec
LENGTH, L ≈ 4 km

	LABILE	REFRACTORY
Mass transfer coefficient for uptake (from chambers) v_f	.04 h	0.0006 h
Turnover time, $T = d/v_f$	5 h	14 d
Turnover Length, $S = v_w T$	2 km	144 km
EOC Utilized within 3rd order reach	57%	1%
labile + refactory	35%	
Theoretical peak EOC Concentrations	0.4 mg/L	0.4 mg/L

FIGURE 6.

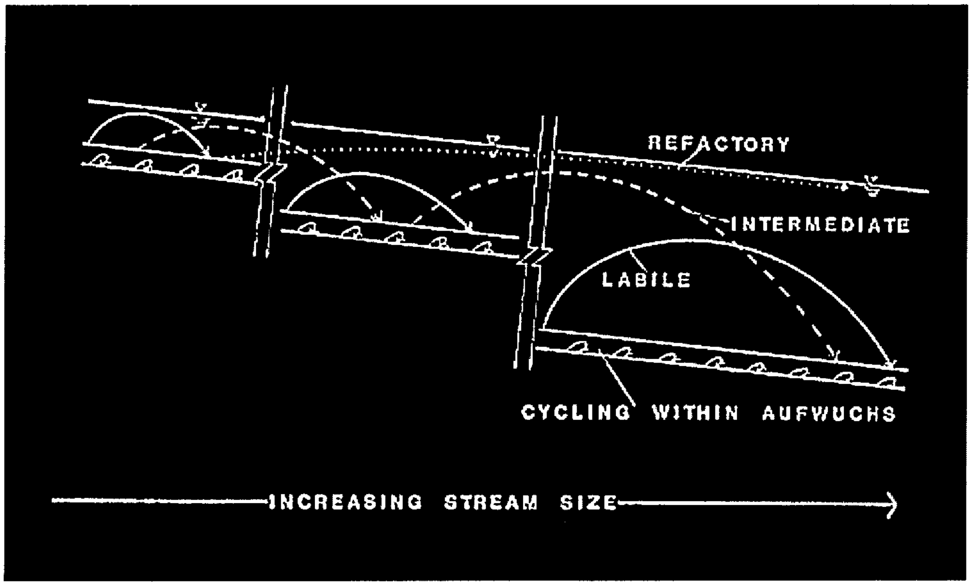


FIGURE 7.

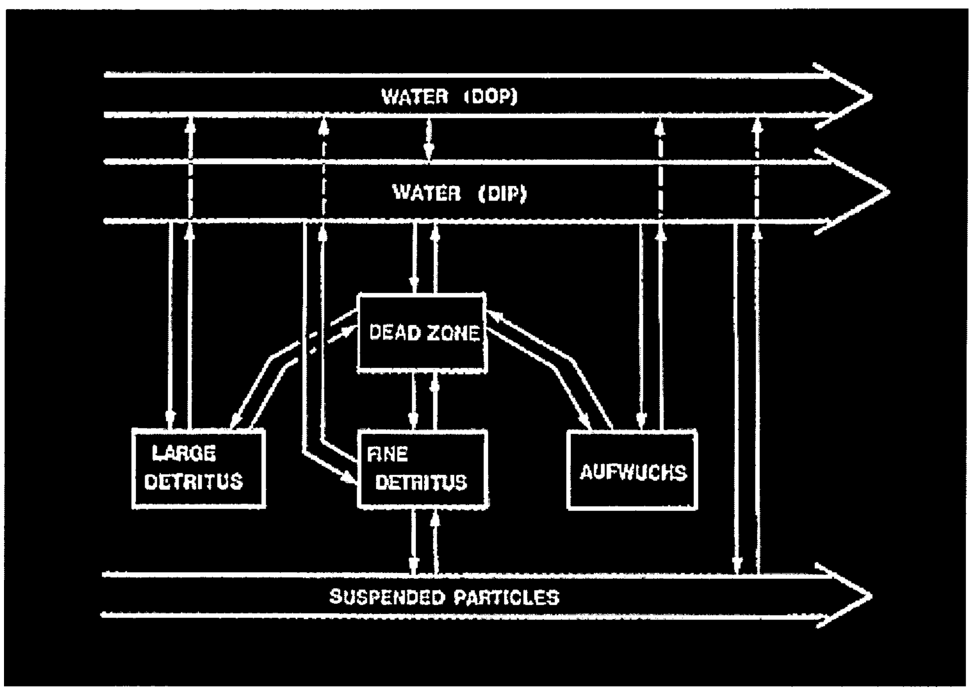


FIGURE 8.

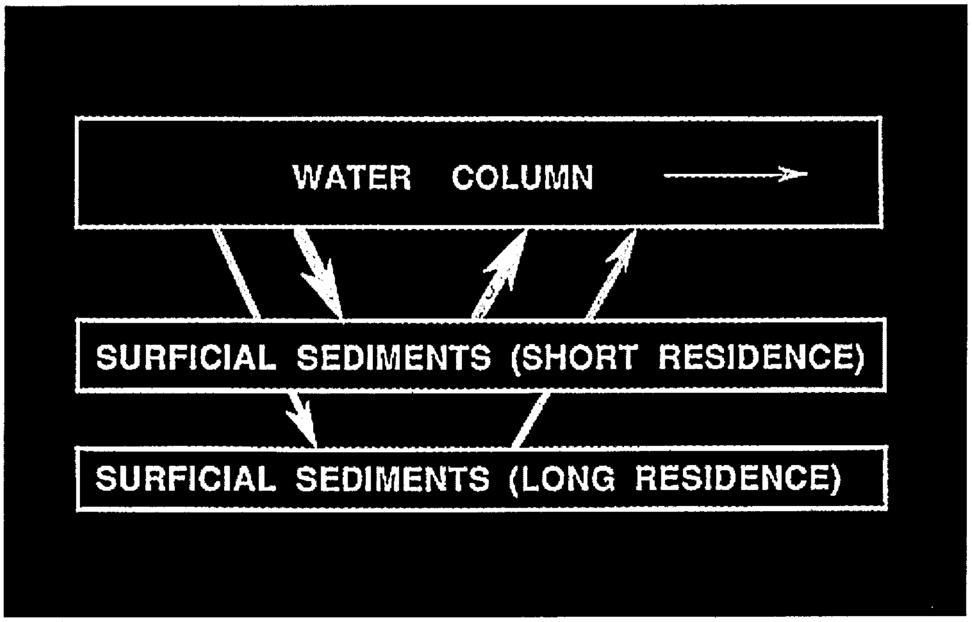


FIGURE 9.

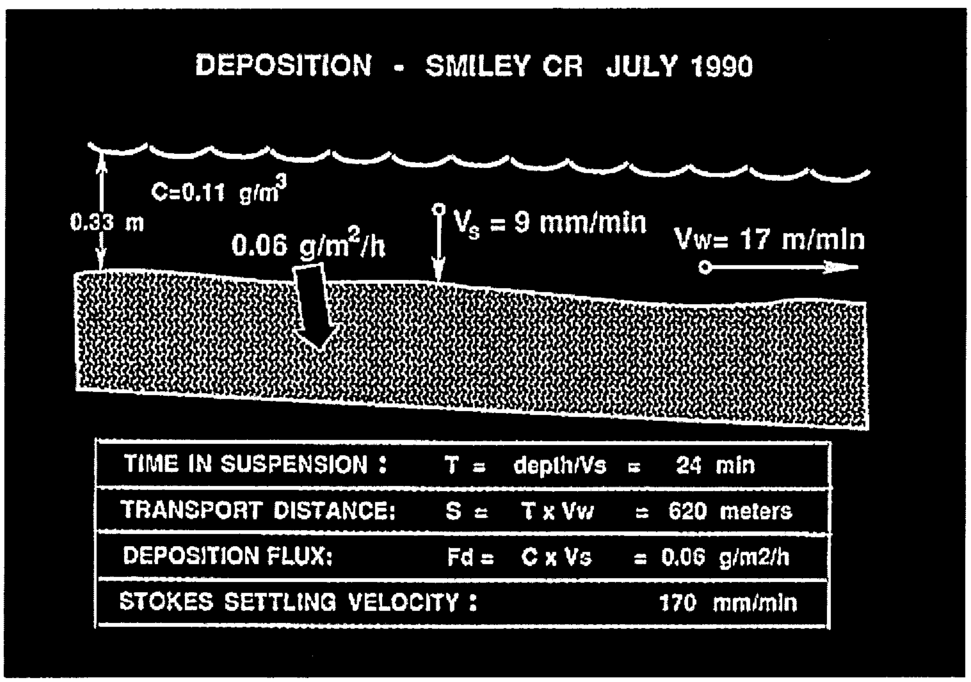


FIGURE 10.

transport distance for seston was 620 m (Figure 10). Again, this distance is on a scale with the length of stream we're talking about. By following these particles, we can say that a particle moves downstream 620 m, sits on the bottom for a period of 24 minutes (part of the fraction stays much longer), then it's resuspended and moves downstream another 620 m. **So** this material can move downstream great distances.

We know that downstream waters in estuaries are heavily dependent upon allochthonous carbon from upstream. This slide (Figure 11) shows a summary way of looking at turnover length concept. We can look at how long something lasts (wood lasts a long time, labile dissolved organic carbon may last only a few minutes, everything else is somewhere in between), vs. how fast it moves downstream; wood doesn't move very fast, both kinds of dissolved organic matter move downstream just as fast as the water moves. Different kinds of materials show tremendous ranges of turnover lengths. Drifting macroinvertebrates tend to stay put. Very fine particulate organic matter can move 10,000 km downstream, generally putting it into the ocean, refractory even farther, and on its way it feeds larger systems, rivers and estuaries.

[Overheads]:

1.

$$\text{Stream Ecosystem Efficiency} = \frac{\text{Inputs - Outputs}}{\text{Inputs}} = \frac{\text{Respiration}}{\text{Inputs}}$$

This reiterates some of the material Bruce was talking about. This is a basic way that we have of looking at processing in headwater systems: Stuart Fisher's concept of stream ecosystem efficiency.

2. The interesting thing is that while stream ecosystems tend to have a range of efficiencies, the basic median stream ecosystem efficiency is about 50% regardless of the size of the watershed. Stream ecosystem efficiency is not tembly dependent on size. We don't see a real trend, which is counter to what a lot of us thought earlier on... some thought that the bigger the stream, the more efficient.

3. As a general rule of thumb, about half of all the inputs to any stream get exported downstream, although it does have a range of 10 to 80 percent at the extremes. **Q - AND IT CHANGES OVER THE YEAR, RIGHT? NEWBOLD - THIS IS AN IDEALIZED, LONG-TERM AVERAGE. THE NUMBER MAKES NO SENSE ON *AN* INSTANTANEOUS BASIS, BECAUSE YOU HAVE STORAGE, ETC. IT ONLY MAKES SENSE ON A 10-YEAR TIME SCALE. UNFORTUNATELY IT HASN'T BEEN MEASURED ON A 10-YEAR TIME SCALE; THESE ARE APPROXIMATIONS.**

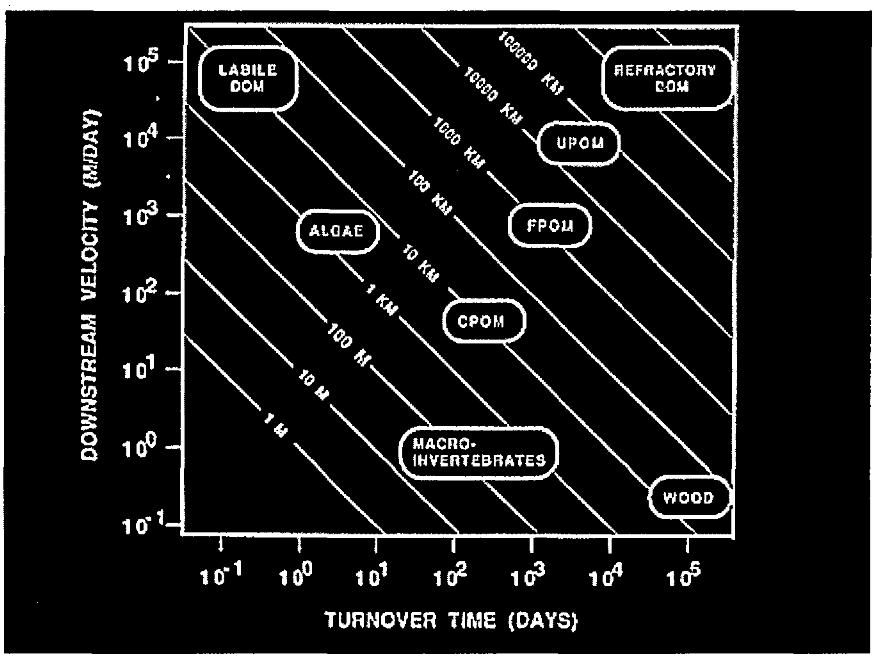


FIGURE 11.

4. This is something Bruce laid out, and I want to make a point on the issue of the inputs. We have litterfall, primary production (which now that we know how to measure it, can be more important in shaded streams than we had thought), and groundwater dissolved organic matter. Deep groundwater sources almost everywhere have low concentrations of dissolved organic matter, and that tends to be highly refractory because it's already been processed; it's been through the ground and there's not much left. But when you look at a stream, it has lots more kinds of dissolved organic matter, there's what's coming from the stream bed and the soil and riparian drainage that tends to be higher concentration and labile.

I don't know much about these fills, but when you think about a fill, you can think about rain coming onto the ground, picking up organic matter from grasses leaching down through, going through the standard process that happens to organic matter as it goes through the ground; it becomes this low-concentration refractory. Even though there's not a stream there, it will go through the ground, and eventually it will emerge below the fill, yielding low concentration refractory; it might be at about the same concentration it would have been without the fill. Yet the water emerging from the fill would be missing the labile dissolved and particulate organic matter, that would have been produced by the stream that is now buried, and it is this labile portion, produced within the stream itself, that supports downstream metabolism. We've calculated in the White Clay Creek that this labile fraction can account for about 20-30% of the metabolism of the stream in the reach.

5. Turnover length and stream organic matter budgets. **As** you get into larger and larger streams, the turnover length increases. In the smallest streams (10 liters per second down to 1 liter per second), turnover length tends to be about 1 kilometer. This material, even from these smallest streams, tends to move downstream about a kilometer, and feed the downstream reach. In terms of budgets, about half of it makes it that far down.

6. Turnover length of carbon is 1 kilometer or longer in first and second order streams. Turnover length increases with stream size. Organic matter cascades in increasingly larger systems.

7. Summary: **A** significant fraction of exported organic matter '(OM) originates within the stream ecosystem and is labile. This is a combination of the point that says that the soil and the riparian areas next to the stream are a major source of organic carbon. And also, the decomposition of the litter and the primary production of material are also important sources of organic matter that get exported downstream. Most **of** the OM inputs to mid-order streams originated from first and second order streams. Based on these concepts, Bruce and Bern showed some data showing the frequency of first and second order streams. Between 60 and 80% of the water feeding a fourth-order stream came from first- and second-order streams. You can work this math out for any drainage basin. If you go all the way back to the geomorphology text of Leopold et al., and work out their miles of stream length against the stream sizes, each order has about the same bottom area and drains about the same drainage area as every other order. First, second, and third order streams are all roughly equivalent, to within an order of magnitude. **So,** if you're looking at fourth order basins, and you're potentially eliminating the first and second order streams, you find that they are contributing at least half of the water and drainage area and stream bed area to the downstream larger orders. Through this "50 percent rule" they are fully contributing their share, if not more, of the carbon in the system (it tends to be a little more because of the specialized habitat of the first-order systems). ***So*** we can calculate what this carbon influence is -- it's large --a large amount of the carbon is delivered downstream. We know that it's labile. There are some missing links -- such as exactly how that feeds back up into the food web in the downstream waters. But we can come to reasonable conclusions about the likely importance on all these points.

Dr. Jay Stauffer, The Pennsylvania State University, University Park, Pennsylvania

I'd like to talk about freshwater fishes and their role in headwater streams. Most of the time we're talking about brook trout, and ***Cottus*** (sculpins). We look at these as species that are common throughout their range, and in fact a lot of fish and game commissions will stock brook trout. In work that we did in the Potomac River in Maryland, we found brook trout in first and second order streams feeding the Potomac River (which had a pH of 4 or 5 on good days) that had been isolated populations for 150-200 years. We could distinguish these brook trout populations -- we could tell which stream a brook trout came from with about 98% probability. At the time I thought it was because they were isolated by the main channel Potomac River and its low pH. Now I think there are a lot of headwater streams that maintain discreet populations. There was discussion about reduction in genetic flow among aquatic insect populations. For fish, that reduction is even exacerbated because they do not have an aerial stage to their life histories -- they must migrate through water to get from one stream to another -- they can't fly over land barriers. **So** I think a lot of these populations are very much isolated. A former student of mine, Rich Raisley, who is now at Frostburg State University (University of Maryland) is describing many species of *Cottus* -- sculpins -- from many of the headwater streams in Pennsylvania, Maryland, Virginia, and West Virginia. At one time we thought all of these populations were conspecific, but it turns out they're not. **So** I'd like to talk about these fishes and ways of evaluating the potential for these stream systems to be harmed and then their potential to recover.

A lot of fishes that live in riffles are darters ***(Efheosfoma*** or ***Percina*** spp.) -- they seem to be unique to particular stream systems. We've done a lot of instream, behavioral studies (many funded by the U.S. Fish and Wildlife Service) looking at the impact of introduced species on these darter communities -- where they breed, where they live, and what they eat.

The banded darter ***(Etheostoma zonale)*** was introduced into a headwater stream, Pine Creek in Pennsylvania, about 1950, and stayed there for a long time. It wasn't until Hurricane Agnes hit in the '70's that this fish was distributed throughout the Susquehanna River. When this happened, the other fishes (e.g., tesselated darter, ***Etheostoma olmstedi***), hybridized with fishes all through the system. Many of you might be familiar with the Maryland darter ***(Etheostoma salare),*** which occurred in Deer Creek and Swan Creek in the Susquehanna River drainage, just over the Pennsylvania border. This species now, I'm confident, is extinct. We last had a siting of that fish about 10 years ago and we haven't found it since then. Its disappearance was coincident with the introduction of ***E. zonale*** into Deer Creek and Swan Creek by Hurricane Agnes. Once it got into that part of the Susquehanna, ***E. salare,*** the Maryland darter, disappeared.

These headwater streams are particularly important, because if you study evolution and are familiar with the work of Mayr and some other people, you find a founder effect, which is very important in the evolution of species. In many of these headwater streams we have isolated populations that are separated, or sometimes disjunct, sometimes with minimal gene flow with the main body of the population. **So** these fish are a little bit different anyway, they're on the edge of their range. **So** they're very much subject to natural selection, and different forces which probably drive speciation and evolution of these fishes. **So** these headwater areas contain what Mayr and others have called "semi-species," or "incipient species." There might be a population where some taxonomists would not give it species status at the time, but maybe 10 years from now, 100 years from now, or 1000 years from now the speciation process would take place. So these fishes are very important, because they're slightly genetically distinct, they're certainly phenotypically distinct -- they look different -- because they're under different selection pressures and environmental pressures that cause phenotypic plasticity.

So these fishes are a little bit different, and they need to be preserved. I think we need **to look** very carefully at what's in these headwater streams. One of the speakers this morning talked about it's a mistake to go in and alter these things before we know what's in them, We think fish fauna are well-known, and I'll talk about that more later. We have other fish species that have pockets in headwater streams -- they're just isolated in these headwater streams, and there's probably very little gene flow that takes place from one headwater stream to another headwater stream, even within the same drainage area. Even in the White Clay Creek basin, you'll find populations in first order streams that don't exchange gene flow with similar fishes in first order streams in the same drainage basin.

Not all headwater streams are fast-moving, high gradient; we have pools, wetlands areas, we have mud minnows and sticklebacks in there. We have them in West Virginia and Pennsylvania. These are very cold, slow-moving pools where fish live. We talked about differences and comparisons. Many of these fish are the same species that occur at other end of drainage, where they go into the Chesapeake Bay or the Gulf of Mexico -- forms which are sort of saltwater forms but their cousins or brothers or maybe even the same species occur at other end of the drainage. But again, there's very little gene flow or no gene flow from one population that lives in the first order stream and the population living near the Bay or Gulf.

We also find fishes in these headwater streams that are migratory. A lot of the lampreys, for example, occur in these small streams. In doing surveys in Pennsylvania, we're finding that a lot of lamprey populations have been deleted or extirpated -- some because of lampricide, some because of habitat changes that have occurred. We may not find adults there, but ammocoetes, which bury into the mud banks, are present. You'll find the adults there at certain times of the year when they migrate to breed. Some of the redhorse suckers you would also find in small headwater streams, especially those streams that empty directly into large rivers. We're doing some surveys of small streams that empty directly into the Allegheny, and the redhorse suckers, even the juveniles, are out of there by June or July. But early in the Spring, you can go to these streams that you wouldn't think would harbor fishes, and you'll find very large redhorse suckers, white suckers, hogsuckers, whatever.

We also have a series of madtoms. These are small catfish (*Noturus* sp.), and these fishes are unique and a lot of the populations are isolated from one another and are genetically and morphologically distinct -- we can tell them apart; and if they are isolated in these headwater streams they become particularly important.

This slide shows a ***Phoxinus*** species, a dace that appears in headwater streams. This form occurs in Tennessee, in just two small tributaries. Last week somebody sent me a ***Phoxinus*** from Virginia to identify, and it turned out to be an undescribed new species. A lot of us have spent a lot of time studying the fish in streams all over Virginia. You take a State with a well-described fish fauna like Virginia, and all of a sudden you come up with a whole new species! It was from **a** second-order stream. It's probably confined to that second-order stream, it probably occurs in no other second-order stream in the Clinch River.

We also have a series of dace - *Clinostomus* spp., a species that is found in first, second, and third order streams. Many of the populations are disjunct; you'll find them in one stream and you don't find them in another stream. So, there are a lot of fishes that are unique to these areas and we're making a mistake deciding to go into these areas and alter these streams until we have a really good knowledge what the fauna is, not just the insects but the fish. Fish are thought to be better known (fewer species, there's not so many life stages, it's easier to identify juveniles, etc.), and so on the surface you think, Oh, the fish fauna's pretty well known, and so if we wipe out this headwater stream we're not doing anything we're not going to be able to live with; we're not going to extirpate a species; and I just ask you to be a little cautious when you make that decision, because there are a lot of these unique populations that are called the same species but are different phenotypically, different genetically, and may in fact be a semi-species or even have achieved specific status at some point, maybe not in your lifetime but maybe in your grandchildren's lifetime. **So** it's something we need to preserve and something we need to examine.

I mention that and you might think, "Things don't evolve that fast." I also do a lot of work in Lake Malawi in Africa, and I'll tell you this quick story just to drive home my point. There's an island in Lake Malawi about 500 m from where my research station is. There are women in the village that talk about their fathers farming the land between where my research station is and that island. The island isn't very old; the lake water came up and made it an island. There are species of fish that occur at that island that occur nowhere else in Lake Malawi. We're talking about speciation that occurred within two generations of humans. So these things can happen very quickly.

When we look at assessment of ecosystems, the evolution assessments went from species/area curves, diversity indices, oligotrophic/heterotrophic ratios, Karr's biotic indices, etc.. When we look at flowing systems, we classify based on calcium content, distribution of fauna. First order streams generally have higher gradients than other orders, but we find exceptions. I studied a stream in the Conowingo Creek basin where the highest gradient was just where it went into the Susquehanna. We found headwater-type organisms -- so gradient has had a profound effect on the fauna found.

Why use fishes for study? Factors: they occupy the top of the food chain; they pass through other trophic levels; they are taxonomically well studied; there's generally more information available on life history.

Species succession in stream fishes is usually a factor of species addition rather than one of replacement.

I have been studying common shiners and striped shiners in headwater streams, in an area where there has been quite a lot of stream capture events among Atlantic Slope, Allegheny river, and Great Lakes drainages. In these areas I postulated that there would have been mixing of the populations and subsequent gene flow among them. I also found some other areas where we find a sibling species (one that morphologically resembles the common or striped shiner) where none of these so-called intergrades occur; thus, a distinct form is present. I have what I think is a new species where none were ever caught before. This occurred in headwater streams.

When looking at streams, as we go down through the drainage basin, we talk about the potential recovery of systems that have been damaged. I was successful in implementing such a program when I was at the University of Maryland, relative to giving mine permits. I persuaded the Maryland Bureau of Mines to give permits for one headwater area, and insisted that it be reclaimed, before a permit in an adjacent headwater area was granted, so we could save refugia in the system.

Cairns and Dickson proposed the concept of inertia -- how hard could we shove this system in terms of stress before structural components of the ecosystem change. They also talk about elasticity: How many times can we shove a system, how will that system recover. Another term is resiliency, defined as a rubber band snapping back. We can stretch the rubber band many times and it comes back; but we get to a point where the band breaks. Do streams act the same way? We don't understand that very well.

Considerations associated with the concept of "inertia":

1. Are the indigenous organisms accustomed to variations? Headwater streams are fairly stable, compared, for example, to estuarine environments. Estuarine organisms would be more used to varying conditions, and thus perhaps contribute more inertia to the system.

2. Structure - is there a lot of structural redundancy in the stream? I've been studying French Creek, a fourth order stream in northwestern Pennsylvania, one of the most diverse streams in the State. There's a lot of structural redundancy. In a particular riffle there are thirteen species of darters. There's **a** lot of functional redundancy -- they overlap a lot, do a lot of the same things. If you lose one species, it would probably not be as critical to French Creek as it would be to a headwater stream. A lot of these headwater streams (first and second order) have only two or three species of fish -- if you lose one of those species, you lose a third of your fauna, which is a structural change, and you lose a lot of functions as well, because there's not a lot of overlap. There's only one species of darter, or only one *Cottus* -- there's not thirteen of them. ***So*** it makes a more drastic impact.

3. The presence of buffered water antagonistic to toxic substances. Headwater streams don't have nearly the built-in protection -- physically or environmentally -- as fourth or fifth-order streams. A lot of these streams don't have the safeguards built into them to resist a functional or structural change.

4. How close the system is to a major ecological transitional threshold. We have a lot of headwater streams where the canopy has been removed, where the temperature in summer gets close to the lethal limit for brook trout; the winter limit gets close to the upper limit of egg production and embryo development. So that stream is close to a transitional threshold, and it won't take a lot of environmental change to push it over the edge.

5. The presence of a drainage basin management group with a water quality monitoring program. Headwater streams are vulnerable because they don't get a lot of attention from fishermen, biologists, etc., compared with larger downstream areas. A fish kill could happen in a headwater stream, and no one would know or call for remediation action.

Considerations associated with the concept of "Elasticity" (the parameters that play an important role in the ability of an ecosystem to recover once it's been damaged.)

1. Existence of nearby epicenters for providing organisms to reinvade a damaged ecosystem.

We can say that the Atlantic Ocean has a lot of inertia -- it's so big, it's well buffered, it can take a lot of stress without showing a change. What happens if the Atlantic Ocean is damaged - if it shows a structural and functional change? Where are the epicenters from which recolonization would take place? There aren't any. Take a headwater stream where *Phoxinus cumberlandensis* occurs. Talk about the unique insects that were talked about today -- they only occur in one place. There aren't other epicenters from which recolonization can take place if that stream is shoved functionally or structurally. Look at Pennsylvania, look at the stream maps. Some have dendritic networks; it looks like there are a lot of streams that could be a source for recolonization to take place. But what if that new species of mayfly only occurs in two of them? Where's recolonization going to take place? These streams are very fragile and have very low inertia, and I would also argue that their ability to recover is also compromised because they're so unique and so different.

2. Another thing that affects elasticity is mobility of any disseminules (life stages) of the organisms present. As I alluded to earlier, in those streams that were clearcut and flowing into the Potomac River in Maryland and West Virginia, the fish fauna was eliminated and so were aquatic insects. You can go back today and can find good aquatic insect populations, but they're still devoid of fish. Aquatic insects can fly and recolonize to some extent and even some of them are confined. Recolonization of fish could not take place, because they had to come up from one headwater stream to another and migrate through the Potomac River. With a pH of 4, that didn't happen very often. So, you have to look at the mobility of the life stages of the critters that inhabit these streams and the potential for them to get from one stream to another.

3. We have to look at the condition of the habitat following the stress. Question: if you put a stream on one of these benches, is it going to be the same? The condition of the habitat is going to be different -- you're not going to have the canopy, the gradient, the soils that you had. If you're a fish, you're not going to have the insects to support you -- it's going to change. So, those kinds of changes make a big difference on this recovery. And so, people say "recovery": Are we satisfied if something can live in the system? Are we satisfied if something different lives in the system but serves the same basic functions? Or do we want to define recovery as putting that stream or that ecosystem back to the way it used to be? These are several different levels that have quite different answers.

4. Elasticity -- The presence of residual toxicants. If you change the substrate, the soils, does that affect the ability of a particular stream to recover to the way it was before?

5. Chemical, physical environmental quality after the stress: How did we alter the system, and how is it physically or chemically different from the way it used to be?

6. Management or organizational capabilities for immediate control of the damaged area. Are there organizations there that will reintroduce the fauna? Are there organizations that know enough about how to introduce the native fauna? If we take brook trout and scatter them all over Pennsylvania and they interbreed with native brook trout populations, have we somehow diluted the gene pool of the native brook trout? Have you changed the ability of the native trout to inhabit that particular system?

These are all things that need to be considered in making a decision about the EIS, about recovery. You need to define recovery, and put in your minds "What kind of chance am I going to take with this ecosystem if I structurally or functionally change it?" and if I get to the probability where I do change it, no matter how small that probability may be, are there other refugia or other ways I can rehabilitate the system or reintroduce the fauna and flora to bring it back to its natural condition, or isn't this even an important question to ask? It makes a big difference if there are unique fauna in that stream. I would argue that, if there's a headwater stream that's the only stream in the world that contains this particular species, we're not going to take any chance with it. And if you want to mine coal or gold or silver or whatever under that stream, we're not going to allow you to do that, because we're not going to take a chance that we're going to lose that genetic diversity of this fish, this mayfly, or this stone fly, or whatever.

WALLACE - I WOULD ADD ANOTHER VERTEBRATE TO THAT GROUP -- SALAMANDERS. THEY ARE VERY LIMITED TO A FEW LOCATIONS IN THE APPALACHIANS. **STAUFFER** - RIGHT. A LOT OF HELLBENDER POPULATIONS ARE REALLY ISOLATED AND DISJUNCT FROM ALL OTHER POPULATIONS.

HANDEL - IS THERE A MINIMUM SIZE STREAM THAT CAN SUPPORT A FISH COMMUNITY? **STAUFFER** - NO. THERE ARE SOME SMALL STREAMS THAT DON'T SUPPORT FISH COMMUNITIES, BUT I'VE FOUND FISH COMMUNITIES IN BASICALLY SINKHOLES. WE WERE SPEAKING OF INTERMITTENT STREAMS, WHERE THE STREAMS DRY UP AND YOU THINK THERE'S NO FISH IN THEM, BUT YOU KEEP GOING BACK YEAR AFTER YEAR, AND YES THERE ARE. THERE ARE SOME FISHES IN FLORIDA (***JORDANELLA***) THAT HAVE -- FOR LACK OF A BETTER TERM -- ANIMAL SEED, AND CAN LIVE FOR ONE YEAR IN TRULY INTERMITTENT STREAMS. THEY LAY THEIR EGGS, THE EGGS SINK DOWN INTO THE MUD, THEY AESTIVATE AND DRY UP. WHEN THE RAINS COME AGAIN THE EGGS HATCH, AND ***JORDANELLA*** ARE BACK IN THE STREAM. SOME OF THE WORK THAT WE DID IN DROUGHT PERIODS, WHERE WE FOUND RIFFLE SECTIONS IN WEST VIRGINIA, WE FOUND A STREAM THAT HAD A POOL HERE, AND A POOL THERE, **BUT** NO RIFFLE CONNECTING THE POOLS. I THOUGHT THE DARTERS HAD TO BE IN THE POOLS. WE SAMPLED AND WE DIDN'T FIND THEM. I THOUGHT SURELY THE DARTERS HADN'T BEEN ELIMINATED FROM THE SYSTEM, AND OUT OF DESPERATION I STARTED SHOVELING RIFFLES: ABOUT 5 HOURS AND 2 FEET LATER, I FOUND THE DARTERS AMONG THE GRAVEL. **HANDEL** - WOULD YOU POINT-BLANK SAY THAT IN APPALACHIA THERE IS NO STREAM SYSTEM TOO SMALL TO BE IMPORTANT FOR FISH CONSERVATION? **STAUFFER** - YES, I WOULD MAKE THAT STATEMENT.

DISCUSSION: WHAT IS A STREAM. WHAT KIND OF INPUT DO THE REGULATORY AGENCIES NEED FROM THIS ASSEMBLED GROUP TO MAKE THE DECISIONS THEY NEED TO MAKE ON PERMITS IN THE INTERIM WHILE THE EIS IS BEING DEVELOPED?

PASSMORE - FOR OUR WORK THAT WE'VE DONE IN PERMIT REVIEWS AND PRELIMINARY DATA COLLECTION THAT WE'VE DONE, WE'VE USED WEST VIRGINIA'S DEFINITION IN THEIR WATER QUALITY STANDARDS WHEN THEY DEFINE INTERMITTENT AND PERENNIAL. WE KNOW THAT FLOW ALONE IS NOT A GOOD INDICATION OF THE FUNCTION OF STREAMS. WEST VIRGINIA WATER QUALITY STANDARDS DEFINE INTERMITTENT STREAMS AS STREAMS WHICH HAVE NO FLOW DURING LONG PERIODS OF NO PRECIPITATION, AND DO NOT CONTAIN AQUATIC ORGANISMS WHOSE LIFE HISTORIES REQUIRE MORE THAN 6 MONTHS IN FLOWING WATER. FOR ONE OF THE PERMITS, WE LOOKED AT A LOT OF STREAMS THAT WERE INTERMITTENT IN TERMS OF FLOW, WITH A FEW RESIDUAL POOLS HERE AND THERE, BUT WE DIDN'T CLASSIFY **ONE** OF THOSE AS INTERMITTENT UNDER WEST VIRGINIA STANDARDS. THEY ALL CONTAINED MANY AQUATIC ORGANISMS, AND CERTAINLY MANY WHOSE LIFE HISTORIES REQUIRE MORE THAN 6 MONTHS OF FLOWING WATER. THE WEST VIRGINIA WATER QUALITY STANDARDS HAVE AN ECOLOGICAL CONNECT TO THEM.

TIBBOTT - IS THAT CONSISTENT ACROSS ALL OF THE STATES THAT WE'RE DEALING WITH IN THIS EIS?

HANMER - NO. THE WEST VIRGINIA AND THE PENNSYLVANIA STANDARDS ARE THE ONES WE FOUND THAT TRY TO MIX FLOW REGIME AND BIOLOGY, AND WHAT THEY'VE WOUND UP DOING IS BASTARDIZING THE ENGLISH LANGUAGE, BECAUSE BY TRYING TO DISTINGUISH BETWEEN PERENNIAL AND INTERMITTENT -- FOR EXAMPLE, THE SURFACE MINING REGULATIONS ARE THE ONES THAT MAKE DISTINCTIONS BETWEEN PERENNIAL, INTERMITTENT, AND EPHEMERAL. NOW HOW THESE DEFINITIONS AFFECT THE REGULATORY REGIME IS UNKNOWN. MOST WATER QUALITY AND ENVIRONMENTAL REGULATIONS DON'T USE THESE ***TERMS*** IN A REGULATORY SENSE. SO, **ONE** OF THE THINGS WE'RE STRUGGLING WITH IS, RATHER THAN TRY TO SAY THAT SOMETHING IS "PERENNIAL AND THEREFORE. . .," MEANING ANYTHING DIFFERENT THAN WHAT IT SAYS IN THE DICTIONARY, WHICH IS THAT IT FLOWS ALL THE TIME, IS TO FIND ANOTHER WAY OF TALKING ABOUT THE BIOLOGICAL VALUES THAT DON'T TRIP OVER THESE OLDER TERMS AND OLDER WORDS. SO, I THINK WE DO NEED TO LOOK FOR SOME LANGUAGE.

TENNESSEE IS INTERESTING BECAUSE THEY DON'T HAVE ANY DEFINITION, OTHER THAN "WATERS." THEY'RE TRYING TO DEFINE SOMETHING CALLED A "DE MINIMIS" STREAM, AND TRYING TO DEFINE THAT RIGHT NOW. THEY'RE THINKING OF IT IN TERMS OF HAVING A DRAINAGE AREA OF 20 ACRES.

FROM THE STANDPOINT OF THE 404 PROGRAM AND WATER QUALITY STANDARDS, IT'S MORE IMPORTANT TO DESCRIBE THE FUNCTIONAL VALUES, RATHER THAN TRYING TO PUT A NAME ON IT LIKE PERENNIAL OR INTERMITTENT. FROM THE STANDPOINT OF REVIEWING REGULATIONS, WE DON'T HAVE GOOD DEFINITIONS. IT WOULD BE NICE TO HAVE AN "APPALACHIAN COAL FIELD" DEFINITION, OR A COMMON SENSE DEFINITION BASED ON SOME OTHER GEOGRAPHIC SCALE. IN KENTUCKY, ACCORDING TO PEOPLE WE TALKED TO, THEY DEFINE REGULATED SURFACE WATERS OF THE COMMONWEALTH AS THE BLUE LINE STREAMS ON A USGS TOPO MAP, OR A DISCRETE CONVEYANCE WITH A DEFINED CHANNEL, FIELD-CONFIRMED. STATISTICAL RECURRENCE OF LOW FLOW DOES NOT ENTER INTO THE DEFINITION OF A STREAM. SO, THERE'S NOT A SINGLE STATE IN THIS REGION THAT DOES IT THE SAME WAY [AS ANOTHER STATE].

WALLACE - DOES EPA HAVE A DEFINITION OF A STREAM, OTHER THAN ARMY CORPS STANDARDS? HANMER - WE HAVE A DEFINITION OF WATERS OF THE UNITED STATES IN CORPS AND EPA REGULATIONS. BUT, YOU HAVE TO GO OUT AND DEFINE WHAT YOU'RE TRYING TO PROTECT ON AN AREA BY AREA BASIS. OUR DEFINITIONS TENDED TO BE BROAD, TO ALLOW FOR GOING OUT AND MAKING MORE SPECIFIC DEFINITIONS.

WALLACE - LUNA LEOPOLD IN 1994 POINTED OUT IN HIS BOOK "A VIEW OF THE RIVER" THAT ALL OF THESE BLUE LINES ON USGS MAPS ARE MUCH SMALLER THAN ACTUAL STREAM FLOWS, ACTUALLY MUCH SMALLER THAN PERENNIAL FLOW. THEY WERE NOT DONE BY FIELD WORK, THEY WERE DRAWN IN THE LABORATORY. THEY BASICALLY ASSIGNED "WHAT IS A STREAM" TO SOMEONE SITTING INSIDE IN A LABORATORY DRAWING A MAP.

HANMER - I THINK YOU DO WANT TO SAY WHAT IS THE IMPACT? BEFORE YOU DEFINE "WHAT IS A STREAM," YOU ASK "WHY DO I CARE?" AND THE REASON YOU CARE, FROM A REGULATORY STANDPOINT, IS THAT YOU'RE TRYING TO

FIGURE OUT HOW TO REGULATE SOME KIND OF PERTURBATION. MINING COMPANIES ARE IRRITATED THAT SOME OF THE SAME PERTURBATIONS ARE DEFINED AS NON-POINT SOURCES UNDER THE CLEAN WATER ACT AND THEREFORE NOT REGULATED, AND ARE DEFINED AS POINT SOURCES UNDER THE CLEAN WATER ACT AND ARE REGULATED, AND IT SEEMS ARBITRARY. AND IT IS, TO A CERTAIN DEGREE, ARBITRARY. HERE WE'RE TRYING TO DISCUSS PHYSICAL PERTURBATIONS. WATER QUALITY STANDARDS WERE DEVELOPED WITHOUT MUCH CONSIDERATION FOR PHYSICAL IMPACTS, THEY WERE DEVELOPED TO CONTROL CHEMICAL INPUTS, AND THEY WERE MOSTLY CONCERNED WITH DEFINING LOW FLOW FOR THE PURPOSE OF SAYING WHEN STANDARDS WOULD BE ALLOWED TO BE VIOLATED. SO THE HISTORY OF THIS WAS A DEVELOPMENT UNDER A "LOGIC STREAM" FOR A PURPOSE. NOW WE NEED A NEW "LOGIC STREAM" THAT SAYS WE'RE CONCERNED ABOUT PHYSICAL PERTURBATIONS, PHYSICAL DESTRUCTION, AND THEREFORE, YOU SAY WHAT KIND OF LOGIC, WHAT KINDS OF DEFINITIONS DO YOU WANT TO CONSTRUCT IN A CASE LIKE THAT. AND THE MOST IMPORTANT QUESTION FOR US IN TERMS OF MITIGATION AND PREVENTION IS THE WORD "SIGNIFICANCE" -- IN OTHER WORDS, IT'S NOT THE MERE EXISTENCE, IT'S ALSO THE SIGNIFICANCE, BECAUSE AT THE END OF THE DAY IF YOU WANT TO STOP SOMETHING FROM HAPPENING, THEN YOU HAVE TO TALK ABOUT SIGNIFICANT ENVIRONMENTAL IMPACT AND WHAT DO YOU MEAN BY THAT.

PASSMORE - IN WATER QUALITY STANDARDS, THERE ARE FOUR COMPONENTS: NARRATIVE CRITERIA (SEDIMENTS, SOMETIMES TOXICS), NUMERIC CRITERIA (MORE TRADITIONALLY WHAT PEOPLE THINK ABOUT AS WATER QUALITY STANDARDS, FOR EXAMPLE DISSOLVED OXYGEN CAN'T BE LESS THAN 5 MG/L), AND DESIGNATED USES, WHICH IS VERY IMPORTANT AND OFTEN WHAT WE'RE TRYING TO PROTECT AND MOST STATES HAVE A BLANKET DESIGNATED USE FOR ALL OF ITS WATERS THAT SAYS THAT THE STREAM HAS TO SUPPORT THE AQUATIC LIFE THAT SHOULD BE THERE. THE AQUATIC LIFE DESIGNATED USE IS OFTEN THE STANDARD WE USE WHEN WE THINK ABOUT WHAT WE'RE TRYING TO PROTECT. IF THE AQUATIC LIFE IS THRIVING AND DOING WELL, WE FEEL THAT THE OTHER PARAMETERS ARE PROBABLY DOING WELL. AND THE FOURTH IS ANTIDEGRADATION. SO, THERE ARE AT LEAST FOUR ELEMENTS OF WATER QUALITY STANDARDS, AND THE TRADITIONAL CHEMISTRY IS ONLY A TINY PART OF WATER QUALITY STANDARDS.

QUESTION - WHAT ARE SOME OF THE CRITERIA THE EPA USES FOR THE BIOLOGICAL ASSESSMENT? A SIGNIFICANT CHANGE FROM WHAT WOULD BE NORMAL? THERE REALLY AREN'T ANY ESTABLISHED BIOLOGICAL CRITERIA.
PASSMORE - MOST OF THE STATES HAVE SOME TYPE OF NARRATIVE CRITERIA THAT COVERS AQUATIC LIFE.

HANMER - WHEN YOU ARE CONTEMPLATING THE PHYSICAL DESTRUCTION OF A STREAM, WHICH IS WHAT YOU HAVE WHEN YOU HAVE A FILL, THERE'S ANOTHER SECTION OF THE LAW WHICH CONTAINS THE RULES, AND IT'S SECTION 404. THE FIRST THING YOU HAVE TO CONSIDER ARE THE 404(B)(1) GUIDELINES, WHICH *ARE* AVOIDANCE- OR TECHNOLOGY-BASED: WHY IS IT THAT YOU HAVE TO FILL IN THE STREAM? WHAT ARE THE ALTERNATIVES? WHAT CAN YOU DO TO AVOID THE IMPACT? SO YOU DRIVE MINIMIZE, MINIMIZE, MINIMIZE AS FAR AS YOU CAN GO, AND THEN YOU SAY WELL, THIS ACTIVITY HAS TO TAKE PLACE HERE (FOR EXAMPLE, THIS IS WHERE THE COAL SEAM IS), AND THIS IS THE SIZE OF THE OPERATION YOU GET TO THE POINT WHERE YOU ARE CONVINCED THAT THE ECONOMICS OF THE OPERATION WOULD NOT TAKE PLACE BUT FOR THE FILL. AT THAT POINT, YOU'VE FINISHED THE MINIMIZATION JOB, AND YOU SAY WHAT CAN BE DONE TO AMELIORATE THE IMPACTS TO TRY TO DETERMINE WHAT IS THE LONG-TERM, PERMANENT IMPACT HERE (WHICH GIVES YOU AN INTENSE INTEREST IN QUESTIONS LIKE WHAT IS THE EFFECTIVENESS OF LONG-TERM RESTORATION TECHNIQUES). AND THEN FINALLY, ONCE AN APPLICATION PASSES THROUGH ALL OF THOSE TRIGGERS, THERE MAY BE A CIRCUMSTANCE WHEN THE GOVERNMENT WILL STILL NOT ALLOW THE IMPACT TO TAKE PLACE: THAT'S WHERE YOU GO TO THE ENVIRONMENTAL TRIGGER, AND THAT TRIGGER HAS THE WORD "SIGNIFICANT" IN IT, AND NO ONE KNOWS HOW TO DEFINE IT EXCEPT ON A CASE-BY-CASE BASIS. THIS IS WHY WE'VE BEEN ACCUSED OF NOT CARING ENOUGH ABOUT INSECTS, BUT GENERALLY "SIGNIFICANCE" IS NOT A SCIENTIFIC TERM; IT'S A VALUE-LADEN, PUBLIC-RELATIONS ... IT HAS A LOT IN IT BESIDES SCIENCE. **BUT** THE KIND OF CONVERSATION WE'VE HAD **THIS** MORNING IS INFORMING THE WHOLE CONVERSATION ABOUT WHAT SIGNIFICANCE IS. BUT THE WATER QUALITY STANDARDS BASICALLY GO AWAY, ONCE YOU HAVE SAID "YES" UNDER 404(C), YOU'VE TURNED A WATER OF THE UNITED STATES INTO A LAND OF THE UNITED STATES -- IT NO LONGER IS A WATER OF THE UNITED STATES -- AND THEN THE WATER QUALITY STANDARDS PICK UP BELOW. THERE'S ONLY ONE CIRCUMSTANCE UNDER THE CLEAN WATER ACT WHERE WATER QUALITY STANDARDS CEASE TO EXIST, AND THAT'S WHEN WATER CEASES TO EXIST, AND IT'S ONLY SECTION 404 WITH ITS OWN SET OF REGULATIONS AND GUIDELINES, THAT DEFINES THE CIRCUMSTANCES UNDER WHICH ECONOMIC ACTIVITY IN THE UNITED STATES WILL BE ALLOWED TO DISPLACE A WATER. UNFORTUNATELY, THERE IS MUCH OF THIS GOING ON THAT'S UNREGULATED, BECAUSE IT'S CALLED NON-POINT SOURCE. THERE ARE LOOPHOLES UNDER THE LAW WHERE STATES ARE SUPPOSED TO BE REGULATING, FOR EXAMPLE AGRICULTURE OR OTHER ACTIVITIES -- BUT THEY AREN'T. THERE ARE LOSSES -- DRAINAGE IS OCCURRING IN NORTH CAROLINA ON AN ABSOLUTELY AWESOME SCALE --

AND THAT'S LOSS BY SUCKING IT OUT RATHER THAN FILLING IT IN. IT'S OFFENSIVE, BUT UNDER THE LAW YOU'RE SUPPOSED TO GET A **404** PERMIT AND IF YOU GET ONE YOU COULD BE ALLOWED TO FILL AND THEREFORE IT BECOMES A LAND OF THE UNITED STATES.

WALLACE -EXPLAIN NATIONWIDE **26?** HANMER - ALL OF THE REGULATORY AGENCIES, THE CORPS AND EPA, BEGAN TO LOOK FOR WAYS TO PERMIT LARGE GROUPS OF WHAT WE CONSIDERED DE MINIMIS ACTIVITIES, OR ACTIVITIES THAT WERE SO SIMILAR TO EACH OTHER THAT YOU COULD WRITE A BLANKET REGULATION RATHER THAN HAVE TO ISSUE HUNDREDS OF THOUSANDS OF INDIVIDUAL PERMITS. THE CORPS STARTED OUT WITH 5 CFS, BY TRYING TO DEFINE DE MINIMIS IN TERMS OF THE GEOGRAPHIC AREA AFFECTED, WHICH COULD BE AFFECTED BY A VARIETY OF DIFFERENT FILLING TYPES OF ACTIVITIES. NATIONWIDE 21 IS FOR SURFACE MINING ACTIVITIES REGULATED UNDER SMCRA. IT WAS DONE WHEN SMCRA WAS STILL LARGELY A FEDERALLY-REGULATED PROGRAM. THE RATIONALE WAS THAT THE SMCRA PROCESS AND NEPA SHOULD INCORPORATE ALL THE TYPES OF CONSIDERATIONS THAT WERE RELEVANT TO PROTECTING THE ENVIRONMENT, AND IF IT DID, THEN THE CORPS WOULD NOT IMPOSE A SECOND NEW NEPA REVIEW ON EVERYTHING, BUT WOULD ACCEPT THE RESULTS OF THE SMCRA PROCESS AND AUTOMATICALLY PERMIT. NP 21 SEEMS TO BE A MOSTLY AUTOMATIC PERMIT THAT WAS TACKED ONTO THE END OF A SMCRA PERMIT. THE PROBLEM WAS (THIS IS NOT A CRITICISM OF THE STATES) THAT AS WE DELEGATED TO THE STATES, SOME OF THE ENVIRONMENTAL REQUIREMENTS ASSOCIATED WITH NEPA "FELL OFF," AND A FEW QUALITATIVE DIFFERENCES OCCURRED, AND THE FEELING WAS THAT WE WERE LOSING SOMETHING, PERHAPS.

POLITAN - BEFORE A SECTION **404** PERMIT IS VALID, A STATE MUST **ISSUE 401** WATER QUALITY CERTIFICATION FOR THE PROJECT, AND CERTIFY THAT THE PROJECT COMPLIES WITH STATE WATER QUALITY STANDARDS. SO EACH STATE CAN MANAGE ITS RESOURCES THAT WAY. THAT'S WHERE WE GET INTO THE DIFFERENT TERMS, DOES IT COMPLY WITH WATER QUALITY STANDARDS?

HANMER - ONE OF THE FACTORS WITH SECTION **404** IS THAT THE STATE HAS AN EFFECTIVE VETO OVER THE ISSUANCE OF A **404** PERMIT. TAKE TROUT STREAMS -- FOR EXAMPLE, IF STATES TRY TO USE THEIR WATER QUALITY STANDARDS TO SAY NO TO ALL TYPES OF FILL, THE STATE LEGISLATURE PROBABLY VERY QUICKLY DOES SOMETHING TO THAT STATE AGENCY. BUT THE STATES ARE EXPECTED TO IDENTIFY SPECIAL WATERS, AND YOU GET INTO WHAT DO YOU MEAN BY THAT, TROUT STREAMS? WHAT HAVE PEOPLE BEEN WILLING TO DESIGNATE IN THEIR STANDARDS AS SPECIALLY-PROTECTED WATERS.

AS A REGULATOR, THE QUESTION IS, WHAT DO BIOLOGISTS HAVE TO TELL US THAT CAN BE USED TO DETERMINE SIGNIFICANCE OR VALUES THAT NEED TO BE PROTECTED? SO IT'S A WAY OF DEFINING, BUT IT'S NOT THE SAME THING AS A DEFINITION.

QUESTION - IS THERE *AN* UNDERLYING ASSUMPTION IN THIS APPLICATION OF THE LAW THAT HEADWATER STREAMS ARE LESS IMPORTANT THAN LARGER STREAMS? HANMER - YES, IN MY EXPERIENCE OVER THE LAST **25** YEARS, I WOULD SAY THAT IS DEFINITELY THE CASE. COMMENT - IN WEST VIRGINIA, UNTIL RECENTLY, THOSE HEADWATER STREAMS WERE ALSO GIVEN A DIFFERENT DESIGNATED USE (THEY WERE CALLED "BAIT MINNOW STREAMS") WHICH DIMINISHED THEIR IMPORTANCE. PASSMORE - BUT, THEY STILL HAD TO MEET ALL THE AQUATIC LIFE CRITERIA. QUESTION - SO IF THERE WERE A PERMIT APPLICATION TO DESTROY A FOURTH-ORDER STREAM, THERE WOULD BE A DIFFERENT SET OF CRITERIA APPLIED? HANMER - I WOULD SAY AUTOMATICALLY YES, BECAUSE THE NATIONWIDE PERMIT ORIGINALLY SAID THAT IF THE WATER BODY FLOWED LESS THAN 5 CFS, IT WAS A DE MINIMIS WATER BODY, AND A DE MINIMIS WATER BODY TRANSLATED INTO A DE MINIMIS EFFECT. I THINK THAT WAS SCIENTIFIC IGNORANCE -- THAT'S WHAT YOU'RE TRYING TO TELL US. I MUST TELL YOU THAT HEADWATER STREAMS ARE BEING DESTROYED EVERYWHERE -- FOR WATER SUPPLY RESERVOIRS, EVER PLACE YOU LOOK. IT'S AN AREA THAT BEGAN TO WORRY US SOME YEARS AGO BUT WE DIDN'T KNOW WHAT TO DO WITH IT. WE STILL HAVEN'T KNOWN QUITE WHAT TO DO WITH IT UP UNTIL TODAY, WHICH IS WHY THIS MEETING IS A GOOD MEETING.

POMPONIO - A COUPLE OF POINTS: THE CORPS DID WHAT THEY DID BECAUSE THE VOLUME OF PERMITS THE CORPS EXPECTED TO HAVE TO PROCESS IF THEY HAD TO DO PERMITTING WORK ON ALL THE LOCAL LITTLE THINGS THAT WENT ON, AND THE CONCERN THAT THE FEDERAL GOVERNMENT DIDN'T REALLY BELONG WAY UP IN THE LITTLE HEADWATER STREAMS REGARDLESS OF THE ECOLOGICAL REASONS, BASED ON WHERE FEDERAL INTERVENTION SHOULD OCCUR. IT WASN'T A TOTALLY ECOLOGICAL DECISION ONE WAY OR ANOTHER -- IT WAS A PRACTICAL DECISION. ALSO, THE NATIONWIDE PERMITS NEVER SAID THEY WEREN'T WATERS OF THE UNITED STATES, AND THAT THE CORPS COULDN'T

REGULATE THEM, THE CORPS CAN TAKE DISCRETIONARY AUTHORITY ON ANY AREA. NP *26* GAVE EVERYONE CARTE BLANCHE TO WORK ABOVE THE HEADWATERS, AND NP 21 GAVE MINING COMPANIES EVEN MORE OPPORTUNITY TO DO THINGS IN EVEN LARGER STREAMS.

COMMENT - SO IF THERE'S AN UNDERLYING BIAS AGAINST HEADWATER STREAMS THAT DOES NOT COME FROM A SCIENTIFIC BASIS, THEN THIS ISN'T A SCIENTIFIC ISSUE SINCE DESTROYING THE WATERS OF A SMALL STREAM, FROM A SCIENTIFIC STANDPOINT, ISN'T ANY DIFFERENT THAN DESTROYING THE WATERS OF A LARGE STREAM. IN A SENSE, WE'RE BEING ASKED AS SCIENTISTS TO COUNTERACT A MAJOR SOCIAL BIAS OR A BIAS CONSTRUCTED FOR PURELY ECONOMIC REASONS, THAT HAS NOTHING TO DO WITH THE SOCIAL VALUE OF THE SYSTEM, OR THE SCIENTIFIC VALUE.

HOFFMAN - BUT THE 404 PROGRAM WAS THOUGHT ORIGINALLY TO EXTEND ONLY TO NAVIGABLE WATERS, *SO* THERE WAS ALWAYS A BIAS AGAINST HAVING FEDERAL INTERVENTION IN THE UPPERMOST HEADWATER AREAS. THAT COUPLED WITH THE WORK LOAD ISSUE, DROVE THE CORPS TO DEVELOPING NP *26*. **BUT** NP *26* ALSO HAS THE PROVISION OF BEING REVIEWED EVERY *SO* MANY YEARS, AND AS A RESULT OF THE AGENCIES PROVIDING INFORMATION ON THE IMPACTS, AND DEMONSTRATING THAT THEY WERE CUMULATIVELY SIGNIFICANT, THAT'S WHY THEY WENT INTO REVISING THE EXISTING NP *26* INTO THE FORM THAT IT HAS NOW, WHICH IS GOING TO BE ARGUED AGAIN. WHAT THEY'RE DOING NOW **IS** CONSIDERING EXPANDING IT INTO ALL HEADWATER AREAS, BUT SAYING THAT ANYTHING LESS THAN AN ACRE IS OK TO FILL.

POMPONIO- ONE OF THE REASONS THE FEDERAL GOVERNMENT COULD GET AWAY WITH EXEMPTING ALL OF THAT ACTIVITY ABOVE THE HEADWATERS IS THAT NO **ONE** CONVINCED THE DECISION-MAKERS WHO WERE NOT FIELD BIOLOGISTS OR AQUATIC SCIENTISTS, THAT THERE WAS ANYTHING SPECIAL ABOUT THOSE AREAS. COMMON KNOWLEDGE AND SCIENTIFIC RESEARCH ALWAYS SEEMED TO BE FOCUSED ON THE LARGER WATERS. ALTHOUGH THEY HAD AN INTUITION ABOUT THE VALUE OF THOSE AREAS, THEY COULD EASILY DISMISS AREAS ABOVE THE HEADWATERS. NEED TO DO A BETTER JOB OF EXPLAINING WHY THEY'RE IMPORTANT. IF THERE'S MORE UNDERSTANDING OF THE VALUE OF THESE AREAS, IT WILL EXTEND FAR BEYOND JUST MINING ISSUES.

HANMER - THERE'S UTILITY VALUE, TOO. ENVIRONMENTAL PROGRAMS, OLDER **ONES,** EVEN GOT PAID FOR, MAYBE EVEN STILL DO, GOT PAID FOR FROM SALES OF FISHING LICENSES. CORPS OF ENGINEERS BENEFIT STUDIES: YOU WEREN'T JUST LOOKING AT FISH, YOU WERE LOOKING AT WHETHER THERE WAS FISHING; NOT JUST WHETHER IT WAS SWIMMABLE, BUT WHETHER THERE WAS SWIMMING. COULD YOU ASSIGN ECONOMIC VALUES TO THESE WATER BODIES THAT WOULD THEN INCREASE THEIR "VALUE" THAT WOULD THEN OFFSET THE OPPORTUNITY COSTS YOU WOULD HAVE OF REFUSING TO ALLOW THEM TO BE EXPLOITED FOR MINING OR OTHER PURPOSES. BECAUSE A LOT OF THE DECISION-MAKING PROCESS IS SOCIO-ECONOMICS.

EVERY TIME WE GET CLOSE TO FARMING AND FORESTRY WITH THE CLEAN WATER ACT, WE FIND OURSELVES IN POLITICALLY DANGEROUS TERRITORY, *SO* THESE HEADWATERS STREAMS PROBABLY LOOK LIKE SOMEBODY'S FARM OR SOMEBODY'S SACRED PROPERTY.

WE NEED TO TELL A BIOLOGICAL VALUE STORY THAT WILL ENRICH OUR UNDERSTANDING OF STREAMS, IF NOT OUR DEFINITION. "A STREAM LOOKS LIKE A PILE OF WET LEAVES," RIGHT?

HARTOS - WHAT DOES THE CORPS RELY ON TO DEFINE A JURISDICTIONAL STREAM? DO YOU RELY ON THE STATE STANDARDS? POLITAN - DON'T THEY USE THE ORDINARY HIGH-WATER MARK? [IN RESPONSE, CORPS PERSONNEL INDICATED THAT THEY PERSONALLY ARE NOT INVOLVED WITH PERMITTING, AND COULDN'T REALLY ANSWER THE QUESTION.]

HANDEL - WE HAVE FORMAL DEFINITIONS OF WETLANDS, A FEDERAL MANUAL THAT'S ENORMOUS THAT DEFINES WETLANDS BY HYDROLOGY, VEGETATION, AND SOIL CHARACTERISTICS. MANY SMALL STREAMS HAVE WETLANDS ASSOCIATED WITH THEM. ARE THERE STREAMS THAT DON'T HAVE WETLANDS? SO IS THE ISSUE REALLY TO DEFINE THOSE HEADWATER STREAMS THAT DON'T HAVE WETLANDS ASSOCIATED WITH THEM? HANMER - PROBABLY YES. POMPONIO - IF WE CAN DEFINE WETLANDS BY SOILS, VEGETATION AND HYDROLOGY, IS THERE *AN* ANALOGOUS SET OF PARAMETERS WE CAN USE TO DEFINE A STREAM? SOMETHING ANALOGOUS TO AN OBLIGATE HYDROPHYTE? LIKE FLOW REGIME, ETC.? WALLACE - THE WEST VIRGINIA DEFINITION IS VERY GOOD, IT MAKES A LOT OF SENSE, IT MAYBE EVEN TOO RESTRICTIVE!

HANMER - THE PROBLEM IS THAT THEY USED IT IN ASSOCIATION WITH THE WORD INTERMITTENT -- KIND OF A NON-DEFINITION, IT SAYS IT'S NOT INTERMITTENT, BUT IT DOESN'T REALLY SAY WHAT IT IS.

TIBBOTT - SHOULD WE HAVE A BIOLOGICALLY-BASED DEFINITION? COMMENT - A FUNCTIONAL DEFINITION. POLITAN -- IF WE USE A BIOLOGICAL DEFINITION, WHAT HAPPENS TO STREAMS DEVOID OF LIFE DUE TO AMD? ANSWER - THAT'S AN IMPAIRMENT. HANMER - ARE ANY OF THOSE SITUATIONS NATURALLY-OCCURRING? POLITAN -- I'VE NEVER SEEN A NATURAL AMD SITUATION THAT WIPED OUT A STREAM. POMPONIO - EVEN THE WETLANDS DEFINITION INCLUDES THE PHRASE "UNDER NORMAL CIRCUMSTANCES."

TIBBOTT - I WOULD THINK THAT ONE OF THE RECOMMENDATIONS WHICH COULD COME OUT OF THE EIS WOULD BE A DEFINITION OF A STREAM ACROSS PROGRAMS AND ACROSS STATES. WALLACE - IT'S VERY DANGEROUS TO HAVE ONE DEFINITION THAT COVERS ALL TYPES OF AREAS. THERE ARE SOME AREAS IN THE COASTAL PLAIN OF GEORGIA WHERE STREAMS ARE DRY FOR PART OF THE YEAR. COMMENT - BUT IF WE'RE JUST DEVELOPING A DEFINITION FOR THE AREA OF STEEP SLOPE MINING, IS IT POSSIBLE TO DO? HANMER - AS A PRACTICAL MATTER, I CAN'T SEE HOW WE'RE GOING TO GET ALL THE STATES IN THIS REGION TO CHANGE ALL THEIR REGULATIONS TO A CONFORMING DEFINITION. IT WOULD BE A WASTE OF TIME TO TRY THAT, BUT IT WOULD BE USEFUL TO COME UP WITH A GUIDELINE FOR ALL THE STATES TO DETERMINE WHEN THEY SHOULD BE CONCERNED ABOUT THESE STREAMS AND WHY. REOPENING THEIR WATER QUALITY STANDARDS IS DANGEROUS. POLITAN - WE DO IT EVERY THREE YEARS ANYWAY. HANMER - YES, BUT YOU DON'T OPEN UP THE DEFINITION OF WHAT IS A STREAM EVERY THREE YEARS.

ARWAY - I DON'T KNOW WHY YOU CAN'T USE THE SAME SYSTEM AS WHEN REGULATING DISCHARGERS -- THAT IS, TO ASSIGN THE "POINT OF FIRST USE" -- WHEREVER THERE IS A USE IS WHERE THE STREAM STARTS FROM A REGULATORY PERSPECTIVE. QUESTION -- WHAT IS THE "POINT OF FIRST USE" IN PENNSYLVANIA? ARWAY - IT'S A VERY SUBJECTIVE DEFINITION EMBODIED WITHIN THE REGULATORY PROGRAM THAT ALLOWS THE FIELD BIOLOGIST TO USE PROFESSIONAL JUDGEMENT TO ASSIGN WHERE A PERENNIAL STREAM STARTS AND WHERE THE WATER QUALITY STANDARDS *ARE* APPLIED. RAMSEY - IN WEST VIRGINIA, THAT "BEST PROFESSIONAL JUDGEMENT" BECAME 250 ACRES, SO THERE'S A REAL DANGER IN DOING THAT. HANMER - AND IN KENTUCKY, IT'S THE BLUE LINE. SO, IF YOU WANT TO WORK ON THIS, WHEN IS IT YOU KNOW YOU'RE SEEING SOMETHING YOU WANT? I DON'T THINK THAT ANY OF THESE DEFINITIONS IS THE PROBLEM. THE PROBLEM IS ASSIGNING VALUE FOR MITIGATION AND FOR MAKING PERMITTING DECISIONS.

COMMENT - THERE ARE SCIENTISTS HERE THAT TALK ABOUT HEADWATER STREAMS DISTRIBUTING NUTRIENTS, ETC. -- THAT'S NOT A SOCIETAL VALUE JUDGEMENT ABOUT WHAT'S IMPORTANT. WE KNOW THINGS WILL CHANGE WITH THIS TYPE OF ALTERATION OF THE LANDSCAPE, BUT WHETHER OR NOT SOCIETY WILL ACCEPT IT . . . THAT'S ALL WE CAN DO AS SCIENTISTS. HANMER - THAT'S RIGHT, BUT THE INFORMATION THAT WAS PRESENTED THIS MORNING IS NOT GENERALLY KNOWN, SO THAT SIDE OF THE CONVERSATION NEEDS BEEFING UP, COMPARED TO PEOPLE WHO SAY THEY OWN THE LAND AND SOMETIMES IT'S WET AND SOMETIMES IT'S DRY. THERE'S A RICH OPPORTUNITY TO INFORM THIS DECISION-MAKING PROCESS FROM THE SCIENTIFIC PROCESS.

COMMENT - WHY ARE INTERMITTENT STREAMS ASSUMED TO BE UNIMPORTANT? HANDEL - IT'S ANALOGOUS TO VERNAL POOLS, WHICH HAVE CRITICAL ECOLOGICAL VALUE, BUT ONLY IN A CERTAIN SMALL TIME OF YEAR. THERE ARE CERTAIN STREAMS WHICH ARE DRY FOR MANY MONTHS, BUT STILL HAVE BIOLOGICAL INTEREST. COMMENTER - BUT IT'S AS IF WE'RE EXCLUDING INTERMITTENT AS BEING IMPORTANT, IN THESE DEFINITIONS. WHY ISN'T INTERMITTENT AS IMPORTANT AS PERENNIAL? HANMER - THAT'S A MISUNDERSTANDING. MOST OF THE STATE WATER QUALITY STANDARDS DO NOT DISTINGUISH -- THEY DON'T TRY TO DEFINE INTERMITTENT AND PERENNIAL AND EPHEMERAL FOR PURPOSES OF THE REGULATORY EFFECT. THE SURFACE MINING REGULATIONS DO -- I DON'T KNOW WHAT EFFECT THEY GIVE THOSE DEFINITIONS, BUT THE CLEAN WATER ACT DEFINITIONS ARE NOT BASED ON THE FLOW. MOST OF THE STATES DID NOT TRY TO DO THAT; WEST VIRGINIA IS ACTUALLY THE EXCEPTION IN THIS LIST OF STATES THAT USE THE TERM "INTERMITTENT" IN THEIR WATER QUALITY STANDARDS. THE REST JUST LEFT IT ALONE.

WALLACE - WHAT'S WRONG WITH THE WEST VIRGINIA DEFINITIONS? HANMER - WHAT IS THE DEFINITION USED FOR? THE DEFINITION IS "STREAMS WHICH HAVE NO FLOW DURING SUSTAINED PERIODS OF NO PRECIPITATION AND WHICH DO NOT SUPPORT AQUATIC LIFE WHOSE LIFE HISTORY REQUIRES RESIDENCE IN FLOWING WATERS FOR A CONTINUOUS PERIOD OF AT LEAST 6 MONTHS." WHY DOES WEST VIRGINIA USE THAT DEFINITION? POLITAN - IT'S WHERE WATER QUALITY STANDARDS APPLY. HANMER - SO YOU START WATER QUALITY STANDARDS AT THAT POINT? POLITAN - NO.

IF THERE'S AN AQUATIC INSECT THAT REQUIRES 4 MONTHS OF FLOWING WATERS, IT'S AN INTERMITTENT STREAM, THAT MEANS THAT IF YOU DO SOMETHING TO THAT STREAM, WE CONSIDER IT A SIGNIFICANT LOSS TO THE STATE, WE WANT COMPENSATION FOR IT, OR IT MANDATES PROTECTION -- WE MAY DENY YOU DOING ANYTHING IN THERE. HANMER - SO YOU USE IT KIND OF LIKE PENNSYLVANIA USES "POINT OF FIRST USE" -- IT'S YOUR POINT OF FIRST USE? POLITAN - KIND OF. WET WEATHER STREAMS ARE "STREAMS THAT FLOW ONLY IN DIRECT RESPONSE TO PRECIPITATION, OR WHOSE CHANNELS ARE AT ALL TIMES ABOVE THE WATER TABLE." PASSMORE - AND WHAT HAPPENS TO THOSE STREAMS IN YOUR REGS AS OPPOSED TO INTERMITTENT? POLITAN - IF WE FIND AQUATIC LIFE ... PASSMORE - I THINK PEOPLE IN THE ROOM ARE THINKING THAT THERE'S A DISTINCTION BETWEEN INTERMITTENT AND PERENNIAL, WHEN THERE ISN'T -- THERE'S A DISTINCTION BETWEEN INTERMITTENT AND EPHEMERAL, *SO* PEOPLE ARE MISUNDERSTANDING THAT THEY'RE CUTTING OFF INTERMITTENT STREAMS, WHEN THEY'RE NOT. POLITAN - ... AT LEAST IN WEST VIRGINIA.

COMMENTER - WELL, IN THE CASE AT HAND, ARE WE TALKING ABOUT BEING ABLE TO PREVENT VALLEY FILLS IN ALL STREAMS THAT ARE ACTUALLY CALLED STREAMS? MAYBE WE SHOULDN'T BE TALKING ABOUT THE DEFINITIONS, BUT WHAT WE CAN ACTUALLY <u>DO</u> HERE. . . IT'S NOT QUITE CLEAR TO ME WHETHER WE'VE COMPLETELY GIVEN UP THE PROBABILITY OF PUTTING AN END TO THIS PROCESS OF DESTROYING STREAMS. IT SEEMS TO ME THAT WE HAVE A REASONABLE CRACK AT MAKING A CASE, FROM THE STANDPOINT OF THE CLEAN WATER ACT AND THE VALUES TO THE ENVIRONMENT OF HEADWATER STREAMS, THAT THIS PROCESS SHOULDN'T OCCUR AT ALL. THAT'S THE FIRST STAGE. IF THE ENVIRONMENTAL IMPACT STATEMENT CAN FIND THOSE RESULTS AND ACTUALLY MAKE A CASE THAT THIS PROCESS SHOULD BE STOPPED, IT SHOULD BE STOPPED. OTHERWISE, THEN WE HAVE TO GET INTO ANOTHER LEVEL OF DISCUSSION, OF HOW YOU SORT OF LET SOMEBODY ROB $10 FROM A BANK, BUT NOT $1,000.

HARTOS - IT WAS RECOGNIZED THAT THERE ARE TIMES WHEN YOU NEED TO FILL IN STREAMS, FOR VARIOUS ACTIVITIES, AND THAT'S UNDER THE 404 PROCESS. YOU'RE ALLOWED TO FILL STREAMS. THERE ARE CERTAIN THINGS THAT NEED TO BE CONSIDERED WHEN YOU DO THAT -- THE BIOLOGICAL WEALTH OF THE STREAMS AND OTHER FACTORS. THE 404(B)(1) GUIDELINES APPLY IN THOSE CASES. IT'S A DECISION THAT NEEDS TO BE MADE. AN ARBITRARY "YOU CAN'T DO IT ANYMORE" . . . YOU WOULDN'T BE ABLE TO DO ANYTHING. HANMER - YES, OF COURSE YOU CAN IF YOU GET A 404 PERMIT YOU CAN FILL IN WETLANDS. WALLACE - YOU COULD FILL IN WHITE CLAY CREEK! HANMER - MINING **IS** ONE OF THE MOST DIFFICULT ACTIVITIES TO REGULATE, BECAUSE IT'S GEOGRAPHICALLY RESTRICTED -- IN OTHER WORDS, THE MINERAL RESOURCE SORT OF DICTATES WHERE YOU'RE GOING TO DO SOMETHING. USUALLY WITH BRIDGES OR HIGHWAYS OR PARKING LOTS OR FLOATING CRAP GAMES -- AND WE DO A LOT OF FILLING TO BUILD FLOATING CRAP GAMES IN MISSISSIPPI -- YOU TRY TO ARGUE THAT THEY DON'T HAVE TO PUT THEIR CASINO ON TOP OF THAT WETLAND, OR THEY DON'T HAVE TO PUT THEIR HOTEL ON TOP OF THAT BEACH. THAT'S PART OF THE ARGUMENT YOU HAVE UNDER 404(B)(1) -- WHY DO YOU HAVE TO DO IT <u>THERE</u>? YES, THE MINING COMPANY HAS TO SHOW YOU THEY ABSOLUTELY <u>**HAVE**</u> TO HAVE THAT VALLEY FILL IN ORDER TO EXPLOIT THAT RESOURCE. IF THEY WIND UP SHOWING YOU THAT THEY'VE GONE AS FAR AS THEY CAN GO ON MITIGATION, THEN THE BURDEN OF PROOF SHIFTS BACK TO SOCIETY TO SAY WHY IS THIS WATER BODY *SO* SIGNIFICANT THAT IT CAN'T BE SACRIFICED FOR THIS USE. AND STATES TRY TO GET AHEAD OF THAT -- WHICH WEST VIRGINIA HAS NOT -- BY TRYING TO DEFINE "AREAS UNSUITABLE FOR MINING" BASED ON SOME OTHER SYSTEM. BUT THAT'S HEAVY GOING. KENTUCKY HAS UNIQUE BIOTIC COMMUNITIES ON BLACK MOUNTAIN, WHICH **IS** ALMOST A TEST CASE IN TRYING TO SET ASIDE A LARGE AREA AND SAY "YOU CANNOT TAKE THIS RESOURCE." AND WHAT YOU GET BACK IS "BUT THERE'S A HUNDRED MILLION DOLLARS WORTH OF COAL THERE!"

STUMP - MAYBE WE SHOULD REORIENT OUR THOUGHTS TO THE DRAINAGE AREA IMPACTS VS. JUST THE STREAM CHANNEL -- FROM HERE DOWN I HAVE A BIOLOGICAL COMMUNITY. LOOKING AT A TYPE OF MINING FOCUSED ON MOUNTAINTOPS, ON FILLING FIRST ORDER STREAMS. MAYBE INSTEAD OF FOCUSING ON THE STREAMS WE SHOULD BE FOCUSING ON AMOUNT OF DRAINAGE AREA VS. STREAM CHANNEL. AND IF WE'RE LOOKING AT A DRAINAGE AREA IMPACTED BY MINING, AND THEN A POINT OF OBSERVATION OR EVALUATION DOWNSTREAM OF THAT, AND MAKING DECISIONS, VS. TRYING TO DETERMINE WHERE THE STREAM STARTS AND WHERE THE STREAM ENDS. BECAUSE I SEE THAT STARTING FROM THE RIDGETOP AND GOING ON DOWN, IT'S ALL A BIOLOGICAL COMMUNITY, AND VEGETATIVE COMMUNITY, ALL TOGETHER AND INTERRELATED, SO MAYBE WE SHOULD BE MAKING OUR CUTOFFS MORE ON A DRAINAGE AREA, OR PERCENTAGE OF DRAINAGE AREA, OF THE TOTAL DRAINAGE AREA CUTOFF, IN EVALUATIONS, AND POINTS OF OBSERVATION AND JURISDICTION. WALLACE - I LIKE DENNIS' ANALOGY -- IS IT OK TO STEAL $1, $10, OR $100 OR $1000 FROM A BANK? WHEN DO YOU DRAW THE LIMIT? STUMP - WELL, IN A REGULATORY FRAMEWORK WE'VE GOT LAWS THAT MINING **IS** ALLOWABLE WITH REGULATIONS. AND WE HAVE TO FIND THAT MIDDLE GROUND OF

HOW MUCH <u>CAN</u> YOU IMPACT BEFORE YOU'RE NOT ALLOWED TO DO ADDITIONAL IMPACTS? WE'RE NOT IN A "PRESERVATIONIST" MODE, EXCEPT IN AREAS WHERE IT'S BEEN DETERMINED UNSUITABLE FOR MINING. DENSMORE - IT'S AN ENTITLEMENT PROGRAM.

HANMER - NO, I DON'T THINK IT IS. WE'RE TALKING ABOUT HOW CAN BIOLOGISTS BE THE MOST USEFUL? I THINK THERE ARE A LOT OF PEOPLE WHO ARE GOING TO SIT AROUND AT THE END OF THE DAY MAKING DECISIONS, ECONOMIC, POLITICAL, SOCIAL. BUT HOW IS THE BIOLOGIST'S VOICE BEST HEARD? HOW IS THE SCIENTIFIC INPUT THAT YOU HAVE TO MAKE TO THIS DECISION MAKING PROCESS BEST EXPRESSED? UNKNOWN COMMENTER - FOR WHAT PURPOSE? HANMER -- TO HELP US. MAYBE YOU'RE UPSET ABOUT THE WORD "VALUE." MAYBE IT'S ONLY PEOPLE LIKE US REGULATORS OR MINING COMPANIES WHO USE THE WORD VALUE AND THAT "VALUE" IS ACTUALLY AN ANATHEMA TYPE WORD TO YOU. FUNCTION -- USE FUNCTION, BUT TO HELP US TO ENRICH THE UNDERSTANDING OF THE FUNCTIONS, SO THAT PEOPLE KNOW THEY'RE GIVING UP SOMETHING, AND NOT NOTHING.

KINCAID - WE DO FILL VALLEYS, WE FILL FOURTH ORDER STREAMS. THE CORPS OF ENGINEERS HAS DONE A PRETTY GOOD JOB OF IT. THE DIFFERENCE IS THAT, UNDER THOSE CIRCUMSTANCES, USING TAXPAYER MONEY, WE HAVE TO DO A COMPLETE, DETAILED ENVIRONMENTAL ASSESSMENT. I DON'T THINK IT'S HAPPENING, BUT ARE WE TRYING TO SWEEP THE SENSITIVITY OF THESE HEADWATER AREAS AND THEIR IMPORTANCE UNDER THE TABLE, AT THE EXPENSE OF RUBBER-STAMPING AN EIS? I DON'T THINK WE SHOULD GET INTO THAT POSITION. WE NEED TO DO GOOD SCIENCE, DESIGN THE EXPERIMENTS, COLLECT THE DATA, AND INTERPRET IT, BUT AS PART OF THAT INTERPRETIVE PROCESS WE NEED TO INCLUDE THE UNIQUENESS OF THESE HEADWATER STREAMS.

HANDEL - I THINK IT'S INTERESTING THAT THE CORPS DOES SOMETIMES FILL FOURTH ORDER STREAMS. BUT RECENTLY, SOME OF THE CORPS' OLD ACTIONS ARE BEING REVERSED, AS NEW KNOWLEDGE AND PUBLIC SENTIMENT CHANGE. WHETHER IT'S PULLING OUT DAMS ON SALMON RIVERS OUT WEST TO THE REMARKABLE ACTION IN THE EVERGLADES, THIS IS ILLUMINATED BY NEW KNOWLEDGE AND NEW ATTITUDES. THIS GROUP IS CHARGED WITH DEVELOPING A MODERN UNDERSTANDING OF THESE LITTLE STREAMS TO SAY TO THE GOVERNMENT: "WELL, THESE THINGS REALLY DO HAVE TO BE SAVED, EVEN THOUGH **25** YEARS AGO WE SAID, LOOK THEY'RE TOO SMALL TO EVEN WORRY ABOUT, OTHER VALUES ARE MORE IMPORTANT. IS THIS PARTICULAR REGIONAL PROBLEM GOING TO BE LIKE THE EVERGLADES AND SALMON STREAMS IN OREGON? I'M JUST A BOTANIST, BUT IT SEEMS LIKE A PRETTY STRAIGHTFORWARD PROBLEM. ARE WE AT STATE WHERE WE SAY THE OLD LAWS WERE WELL-MEANING, OF COURSE, BUT WE HAVE TO MOVE ON FROM THERE.

NEWBOLD - THE SENTIMENT OF PROBABLY MOST OF THE PEOPLE IN THIS ROOM IS THAT THIS VALLEY FILLING IS A BAD IDEA, AND THAT THE WEIGHT OF THE SCIENTIFIC EVIDENCE -- THE IMPACT YOU COULD DOCUMENT, ALTHOUGH IT MIGHT BE A LOT OF PROBLEM TO DO IT -- WOULD MAKE A STRONG CASE AGAINST DOING IT AT ALL. YET THE REALITY SAYS WE CAN'T STOP IT. SO, WE HAVE TO STEP BACK AND TAKE A COMPROMISE APPROACH, IN WHICH INSTEAD OF DOCUMENTING WHY IT SHOULDN'T BE DONE AT ALL, WE ARE IN A POSITION OF DECIDING WHICH WATERSHEDS TO SACRIFICE AND HOW MANY, AND COMING UP WITH A SORT OF "CALCULUS" TO DO THAT. THAT CALCULUS IS WELL BEYOND THE FIRST STEP. WE <u>ARE</u>, AS SCIENTISTS, IN A POSITION TO BE ABLE TO SAY THIS HAS A STRONGLY NEGATIVE IMPACT, AND LIST THE IMPACTS, AND SAY THIS IS A PRACTICE THAT SHOULDN'T BE DONE. WE DON'T HAVE THE TECHNOLOGY TO CREATE A CALCULUS TO DECIDE WHAT PERCENT CAN BE DESTROYED. WHERE YOU DO SEE THIS KIND OF REGULATION DEVELOPED, WHERE THERE IS A CALCULUS, IT'S ALMOST ALWAYS A JOKE. IT TYPICALLY IS THE RESULT OF SOME KIND OF POLITICAL COMPROMISE, AND BECAUSE YOU COULDN'T REALLY DO IT RIGHT YOU HAD TO COME UP WITH SOME CRAZY SCHEME OF ADDING A LOT OF DIFFERING COEFFICIENTS TOGETHER OR WORKING THROUGH SOME KIND OF A MATRIX THAT EVERYONE REALIZES DOESN'T MAKE SENSE, BUT IT WAS COME UP WITH AS A COMPROMISE TO COME UP WITH A SLIDING SCALE WHICH ENDS UP IN MIDDLE GROUND.

HANMER - DO YOU REMEMBER LEOPOLD'S "UNIQUENESS INDEX" FROM 1972? MY CHALLENGE TO YOU IS THAT CHANGES OCCUR. THAT DEVELOPMENT OCCURS, AND THAT EVEN BIOLOGISTS LIVE IN HOUSES AND BENEFIT FROM DEVELOPMENT. SO THEN, THE QUESTION FOR US IS, DO YOU WANT THAT TO JUST HAPPEN HELTER-SKELTER, OR DO YOU WANT TO TRY TO FIGURE OUT AND TAKE SOME RESPONSIBILITY FOR IT? THAT'S THE DILEMMA YOU'RE IN. YOU'RE SAYING "I DON'T WANT TO TAKE RESPONSIBILITY SAYING THAT FILLING 10% OF THE HEADWATER STREAMS IS OK" AND I CAN UNDERSTAND WHY YOU WOULDN'T WANT THAT KIND OF RESPONSIBILITY. BUT UNFORTUNATELY, SOME OTHER PEOPLE HAVE TO TAKE THAT RESPONSIBILITY AND IT WOULD BE NICE IF THEY COULD DO IT ON THE BASIS OF THE BEST KIND OF INFORMATION THEY CAN GET.

WALLACE -THERE'S ANOTHER DANGER HERE, ESPECIALLY WHEN YOU CONSIDER LONG-TERM NITRIFICATION OF CATCHMENTS. THERE MIGHT BE THINGS HAPPENING HERE THAT WE'RE NOT GOING TO SEE UNTIL 15 OR 20 YEARS DOWN THE ROAD. ARE YOU GOING TO LET THESE PROCEED NOW, AND THEN FIND OUT 15 OR 20 YEARS LATER THAT THERE'S SOMETHING AWRY HERE THAT YOU CANNOT CORRECT? AND I'M PARTICULARLY THINKING ABOUT POTENTIAL FOR NITRATES IN THE SURFACE WATERS. THAT CAN BE PRETTY DANGEROUS. KINCAID - THAT'S ALL THE MORE REASON WHY WE NEED TO DESIGN GOOD EXPERIMENTS RIGHT NOW. WALLACE - EXACTLY, THAT'S WHAT I'M SAYING. AND THESE SHOULD BE MINIMIZED UNTIL WE SOLVE THE PROBLEM AND HAVE SOME IDEA OF THE WHAT KIND OF DOWNSTREAM EFFECTS THEY HAVE. ROBINSON - THERE ARE SOME VALLEY FILLS WHICH HAVE BEEN IN PLACE FOR 15 YEARS, CAN'T THESE BE STUDIED?

KINKAID - WE'RE TALKING ABOUT PROBLEMS THAT CAN COME TO GET US DECADES DOWN THE ROAD. WE NEED TO DESIGN THE EXPERIMENTS NOW PROJECTING THE PROBABLE IMPACTS, AND DETERMINING THE SIGNIFICANCE OF THE IMPACTS. I DON'T THINK RIGHT NOW, OR EVEN AFTER A YEAR'S WORTH OF DATA, WE'LL BE ABLE TO SORT OUT WHAT WE FIND FROM ENVIRONMENTAL NOISE WELL ENOUGH TO SAY THAT THESE IMPACTS ARE GOING TO OCCUR NEVER, TOMORROW, OR IN 2050. WE NEED TO BUILD INTO THE PROCESS SOME MEANS OF CONTINUING THIS EVALUATION PROCESS, AT THE SAME TIME THAT WE MEET THE DEADLINE.

DENSMORE - I WANTED TO BRING UP HERE, THAT GETS BACK TO THE SORT OF ARTIFICIAL CONSTRUCT WE GET INTO AS LAWYERS AND REGULATORS -- RIGHT NOW WE ARE LOOKING AT A 250-ACRE THRESHOLD FOR "MINIMAL" IMPACTS FOR PURPOSES OF THE PERMIT SYSTEM. THAT IS A NUMBER THAT HAS A LONG HISTORY, AND RELATES HISTORICALLY TO "AT WHAT POINT DO YOU REQUIRE COMPENSATION FOR LOSSES," BUT IT HAS NOW SORT OF JUMPED OVER AND BECOME A THRESHOLD BELOW WHICH YOU DON'T HAVE A SIGNIFICANT IMPACT ON THE SYSTEM. THIS HAS THE DANGER OF BECOMING LAW, THE WAY IT'S BEING USED RIGHT NOW, BECAUSE IT IS BEING USED AS A PRIMARY BASIS FOR PROCESSING CORPS OF ENGINEERS PERMITS.

WALLACE - THIS MEANS THAT ON ANY GIVEN DRAINAGE BASIN, YOU COULD FILL IN A SERIES OF FIRST AND SECOND ORDER STREAMS -- YOU COULD RAID THE BASIN, BASICALLY, AS FAR AS THE HEADWATERS -- EACH WITH SEPARATE FILLS OF UP TO 250 ACRES. HANMER - YOU COULD. DENSMORE - IT'S BEING SO RIGIDLY ADHERED TO THAT YOU COULD FILL 20 BASINS, SO LONG AS YOU KEPT THEM TO 249 ACRES OR LESS. I'D BE INTERESTED IN THE REACTION TO THAT HERE.

STAUFFER - DEPENDS WHICH 250 ACRES YOU'RE TALKING ABOUT. IF IT'S 249 ACRES OF WHITE CLAY CREEK WHERE THIS ONLY MAYFLY OCCURS, SOMEONE'S GOING TO HAVE A PROBLEM. IF IT'S THE 249 ACRES WHERE MY ONLY *PHOXINUS* OCCURS, I'M GOING TO HAVE A PROBLEM.

ROBINSON - IT'S NOT THAT SIMPLE, BECAUSE THERE'S A CAVEAT THAT SAYS THAT IF WE CONSIDER THAT MULTIPLE 250 ACRES BECOME CUMULATIVELY SIGNIFICANT -- AND WE HAVE TO KNOW WHAT THAT MEANS. SO, HOW MANY 250'S DO WE DO BEFORE ... HOFFMAN - OR, THE 249 ON YOUR SENSITIVE CREEK IS SENSITIVE. ROBINSON - OR THERE'S A THREATENED OR ENDANGERED SPECIES OR A WETLAND OR A FEDERAL TRUST RESOURCE.

STAUFFER - SOMEBODY MIGHT NOT WANT TO WIPE OUT A SONGBIRD, SOMEBODY MIGHT NOT WANT TO WIPE OUT A SALAMANDER, AND SOMEBODY ELSE WANTS TO PROTECT A FISH, WANT TO PROTECT A MAYFLY, THEN THE DINOFLAGELLATE AND A BACTERIA, AND YOU'VE GOT A QUALITY JUDGEMENT THERE. I'M PRETTY SURE THAT ALL OF THESE SYSTEMS HAVE SOME UNIQUE ORGANISMS AT SOME LEVEL OR ANOTHER ASSOCIATED WITH THEM. ROBINSON - AND AS REGULATORS, WE LOOK FOR BLACK AND WHITE LINES, AND WE KEEP PUSHING PEOPLE TO TELL US WHERE THEY ARE, AND IT DEPENDS ON YOUR INTEREST AND WHAT PART OF SCIENCE YOU COME FROM AS TO WHAT YOU CARE ABOUT. STAUFFER - IT GETS BACK TO THE $10 OR $1,000: "I'M WILLING TO GIVE UP A FISH BUT NOT A SONGBIRD," OR "I'M WILLING TO GIVE UP A MAYFLY BUT NOT A FISH."

TIBBOTT - WE'VE TRANSITIONED TO OUR NEXT QUESTION: HOW MUCH CAN WE GIVE UP? HOW MUCH CAN WE AFFORD TO LOSE? THERE ARE 40 PERMITS THAT HAVE TO BE DEALT WITH. SIX OF THE 40 HAVE MULTIPLE FILLS UNDER 250 ACRES. THE FISH AND WILDLIFE SERVICE IS THE ONLY AGENCY AMONG THE FIVE AGENCIES THAT CONSIDERS THIS A SIGNIFICANT CUMULATIVE IMPACT; ALL THE OTHER AGENCIES WOULD JUST AS SOON LET THEM GO AS NATIONWIDE

PERMIT AUTHORIZATION. THE FISH AND WILDLIFE SERVICE IS INTERESTED IN YOUR REACTION TO WHAT DO WE DO WITH MULTIPLE FILLS?

ARWAY - JUST A COMMENT ABOUT CUMULATIVE IMPACTS. THERE'S A PROVISION IN SMCRA THAT DEALS WITH CUMULATIVE HYDROLOGIC IMPACT ASSESSMENTS. WHERE STATES HAVE DELEGATED PROGRAMS, THEY HAVE TO DO CHIAS. TO MY KNOWLEDGE, NO PERMIT HAS EVER BEEN DENIED OR ALTERED BECAUSE OF CHIAS. WE'VE BEEN DOING CHIAS FOR A LONG TIME, BUT I'VE NEVER SEEN ANY EFFECT ON THE PERMIT PROCESS. TIBBOTT - I DON'T THINK THEY'VE REALLY BEEN DONE. ARWAY - THE OBLIGATION OF THE AUTHORITY IS THERE, AND THE STATE HAS TO "CHECK THE BLOCK" WHEN IT ISSUES THE PERMIT THAT THE CHIA HAS BEEN DONE. TIBBOTT - ALTHOUGH THE BLOCK IS CHECKED, THEY'RE NOT DONE. ARWAY - WELL, THEY'RE REQUIRED TO BE DONE AND IN THEORY THEY ARE DONE. HISTORY TEACHES US THAT THEY'RE REQUIRED TO BE **DONE,** BUT THEY'RE NOT DONE, AND PERMITS ARE STILL ISSUED.

NEWBOLD - CAN WE GO DOWNSTREAM AND IDENTIFY THE RESOURCES ON WHICH THE CUMULATIVE IMPACTS MIGHT BE FELT; A SPECIFIC REACH OF STREAM, A LAKE, AN ESTUARY IF YOU GET FAR ENOUGH DOWN? IS THAT A USEFUL WAY OF LOOKING AT THE QUESTION? ROBINSON - IT GOES BACK TO WHAT ARE THE VALUES THAT YOU ASSESS, AT WHICH CUMULATIVE PROBLEMS START KICKING IN. NEWBOLD - IF WE GET IN A BOAT AND GO DOWNSTREAM, AND WE COME TO THIS STRETCH OF RIVER THAT'S USED FOR FISHING OR WHITEWATER RAFTING, OR COME TO A LAKE THAT HAS A FISHERY, THEN WE SEE THE RESOURCES AND WE SAY ARE THESE AT RISK OF BEING IMPACTED, SO INSTEAD OF WORKING FROM, "WELL, WE COULD HAVE ALL THESE KINDS OF IMPACTS DOWNSTREAM," AND WORKING THROUGH THAT, WE GO DOWNSTREAM AND SEE WHAT MIGHT BE VULNERABLE AND WHAT MIGHT BE THE IMPACTS. ROBINSON - REGULATORS STRUGGLE WITH "HOW FAR DOWNSTREAM" YOU'RE SUPPOSED TO DEFINE CUMULATIVE IMPACT AREAS. IS IT THE GULF OF MEXICO OR THE CLINCH RIVER OR THE CHEAT RIVER OR SOME TRIBUTARY OF THE CHEAT RIVER. COMMENTER - THE GULF OF MEXICO IS A CANDIDATE BECAUSE THERE ARE NUTRIENT PROBLEMS IN THE GULF OF MEXICO IN REGARDS TO NITRATES. ROBINSON - IF YOU CHOOSE THE GULF OF MEXICO AND WE HAVE TO LOOK AT WATER QUANTITY AND QUALITY AND WELLS AND THINGS, THE POOR CITIZEN WHOSE WELL IS IMPACTED BY UNDERGROUND MINING OR SURFACE MINING, IF YOU'RE LOOKING AT THE GULF OF MEXICO THAT BECOMES AN INSIGNIFICANT IMPACT AND SO YOU CAN WRITE IT OFF. SO WHERE YOU DRAW THE LINE SO YOU CAN EVALUATE IMPACTS IS SOMETHING THAT HAS TO BE DECIDED.